(29,265)

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1922.

No. 715.

ELECTRIC BOAT COMPANY, APPELLANT,

vs.

THE UNITED STATES.

APPEAL FROM THE COURT OF CLAIMS.

INDEX.

JUDD & DETWEILER (INC.), PRINTERS, WASHINGTON, D. C., FEBRUARY 5, 1923.

1 **I. PETITION AND EXHIBIT "A."**

[Filed July 29, 1914.]

In the United States Court of Claims.

No. 32877.

ELECTRIC BOAT COMPANY, Petitioner,
against
THE UNITED STATES OF AMERICA, Defendant.

To the Honorable the Judges of the Court of Claims:

The petition of Electric Boat Company respectfully represents:

1. That it is a body corporate organized and existing under the laws of the State of New Jersey, having a manufacturing establishment at Groton, Connecticut, and having an office at No. 5 Nassau Street, New York, N. Y.

2. That on August 20, 1912, Letters Patent of the United States for improvements in Automobile Torpedoes, No. 1,036,082, were duly granted to your petitioner as assignee of Gregory C. Davidson, whose application therefor was duly filed March 19, 1908, and renewed July 3, 1912; and that said Letters Patent granted to your petitioner the exclusive right to make, use and sell throughout the United States and the territories and possessions thereof, the
2 invention therein described and claimed, for the term of seventeen years from the date thereof.

3. That the said Gregory C. Davidson was the original, first and sole inventor of the said improvements described and claimed in said Letters Patent; that the said invention was not known or used by others prior to his invention or discovery thereof and was not patented or described in any printed publication in this or any foreign country prior to his invention or discovery thereof or more than two years prior to his application for said Letters Patent; that the said invention was not in public use or on sale in this country for more than two years prior to the date of his application for said Letters Patent and was not patented in any country foreign to the United States on an application filed more than twelve months prior to the date of his application for said Letters Patent and was not abandoned by him; that the application for said Letters Patent was duly assigned to your petitioner before the issuance of said Letters Patent by an assignment in writing duly recorded in the Patent Office; and that said Letters Patent were in all respects duly issued and delivered to your petitioner in conformity with the laws of the United States.

4. That on August 20, 1912, Letters Patent of the United States for improvements in Apparatus for Generating Motive Fluid for

Automobile Torpedoes, Nos. 1,036,080, were duly granted to your petitioner as assignee of said Gregory C. Davidson, whose application therefor was filed March 29, 1909; and that said Letters Patent granted to your petitioner the exclusive right to make, use and sell throughout the United States and the territories and possessions thereof the invention therein described and claimed for the term of seventeen years from the date thereof.

3 5. That the said Gregory C. Davidson was the original, first and sole inventor of the said improvements described and claimed in said Letters Patent, No. 1,036,080; that the said invention was not known or used by others prior to his invention or discovery thereof and was not patented or described in any printed publication in this or any foreign country prior to his invention or discovery thereof or more than two years prior to his application for said Letters Patent; that the said invention was not in public use or on sale in this country for more than two years prior to the date of his application for said Letters Patent and was not patented in any country foreign to the United States on an application filed more than twelve months prior to the date of his application for said Letters Patent and was not abandoned by him; that the application for said Letters Patent was duly assigned to your petitioner before the issuance of said Letters Patent by an assignment duly recorded in the Patent Office; and that said Letters Patent were in all respects duly issued and delivered to your petitioner in conformity with the laws of the United States.

6. That by virtue of the assignments aforesaid, your petitioner became, has ever since been and now is the sole and exclusive owner of said Letters Patent Nos. 1,036,082 and 1,036,080, and of the inventions and improvements therein described and claimed, including all claims for damages for infringement of said Letters Patent from the time of the grant thereof, and except for the grant of a license as hereinafter set forth, your petitioner is now the sole and exclusive owner of all rights secured by said Letters Patent and each of them since the date thereof.

7. That prior to the issuance of said Letters Patent, all
4 proceedings were duly had and taken which were required by law to be had and taken previous to the grant of said Letters Patent.

8. That the inventions set forth in said Letters Patent Nos. 1,036,082 and 1,036,080 are adapted for and capable of conjoint use in one and the same apparatus, and that in the apparatus hereinafter complained of they are so conjointly used.

9. That the inventions described and claimed in said several Letters Patent and each of them are and have been recognized to be of great utility and value in the construction and operation of automobile torpedoes; and that since the grant of said Letters Patent on August 20, 1912, your petitioner, in the exercise of the exclusive rights so granted, has been ready and willing to make and vend automobile torpedoes employing the inventions set forth in said several Letters Patent and to grant to others the right to make, use and vend the improvements so patented.

10. That on April 3, 1912, your petitioner entered into an agreement in writing with the United States, a copy of which is annexed hereto and marked "Exhibit A," in accordance with which agreement the United States was licensed and empowered to manufacture on its own behalf, either in its own shops or by contract in private shops, and to use, automobile torpedoes equipped with steam generators containing the inventions set forth in a certain Letters Patent of the United States and in certain applications for Letters Patent of the United States including the applications for said Letters Patent Nos. 1,036,082 and 1,036,080 to the ends of the terms for which said Letters Patent had been or should be granted, and in return therefor the United States agreed
5 to pay to your petitioner a royalty of One Thousand Dollars ($1,000) for each of the first ten torpedoes, Nine Hundred Dollars ($900) for each of the second ten torpedoes, and Eight Hundred Dollars ($800) for each of all additional torpedoes made by or for the United States in accordance with the license granted to it and containing the inventions set forth in the Letters Patent and the applications for Letters Patent enumerated in said agreement, including the applications for said Letters Patent Nos. 1,036,082 and 1,036,080, the royalty provided for in the agreement to become payable when each such steam generator for automobile torpedoes had been tested and accepted by the United States.

11. Your petitioner further shows, upon information and belief, that the United States, through its officers and agents, well knowing the premises and the exclusive rights granted to your petitioner as aforesaid under said Letters Patent, has, since the execution of said license agreement on April 3, 1912, and since the grant of said Letters Patent on August 20, 1912, and from time to time thereafter, at various places within the United States, made or used or caused to be made or used, and is now making or using or causing to be made or used, Automobile Torpedoes and Apparatus for Generating Motive Fluid for Automobile Torpedoes embodying the inventions described and claimed in said several Letters Patent, and has neglected and refused to pay royalty to your petitioner, in accordance with the terms of said agreement dated April 3, 1912, or otherwise, though often requested so to do, all in defiance of the rights granted to your petitioner by said Letters Patent Nos. 1,036,082 and 1,036,080, and in disregard of the obligation upon the United States in accordance with the terms of said agreement dated April 3, 1912.

6 12. That as your petitioner is informed and believes, the Government of the United States, through its duly authorized officers and agents, has made or has caused to be made for it Automobile Torpedoes and Apparatus for Generating Motive Fluid for Automobile Torpedoes employing the inventions described and claimed in said Letters Patent Nos. 1,036,082 and 1,036,080 to the number of approximately Two Hundred Forty (240) since the execution of said agreement on April 3, 1912, and since the grant of said Letters Patent on August 20, 1912; that your petitioner is

unable to state with particularity, without an examination of certain records in the Navy Department, either how many Automobile Torpedoes and how many Apparatus for Generating Motive Fluid for Automobile Torpedoes employing the inventions set forth in said several Letters Patent have been made by or for the United States; and that in order to enable it to state its claim with greater particularity, your petitioner requires access to the records of the purchases of Automobile Torpedoes and Apparatus for Generating Motive Fluid for Automobile Torpedoes from E. W. Bliss Company of Brooklyn, New York, by the Navy Department of the United States and the types of automobile torpedoes so purchased, during the period from April 3, 1912, to the date hereof.

13. That a fair and just compensation to your petitioner for the use of said inventions by the United States as aforesaid is at the rate of One Thousand Dollars ($1,000) for each of the first ten torpedoes, Nine Hundred Dollars ($900) for each of the second ten torpedoes, and Eight Hundred Dollars ($800) for each additional torpedo containing or employing the inventions described and claimed in said Letters Patent, or either of them, making a
7 total of One Hundred and Ninety-Five Thousand Dollars ($195,000) for the said Two Hundred Forty (240) torpedoes, the same being substantially the value of said inventions and the value which your petitioner attributes to the use of said inventions and the value which the United States obligated itself to pay to your petitioner by the said agreement dated April 3, 1912.

14. That your petitioner is the sole owner of the claim set forth in this petition, no assignment or transfer of the said claim or any interest therein having ever been made; and that your petitioner is justly entitled to the amount hereafter claimed from the United States after allowing all just credits and off-sets.

15. That no action upon your petitioner's claim has been had by or before Congress or any executive department of the Government of the United States, and no proceeding is now pending in any Court directed to a settlement of said claim.

16. That at the times of applying for and of the issuance of said several Letters Patent, the said Gregory C. Davison was a citizen of the United States; that he has at all times borne true allegiance to the Government of the United States, and that neither the said Davison nor your petitioner has ever in any way voluntarily aided, abetted or given encouragement to rebellion against the United States; and that said Davison was not, at the times when he made the said inventions, in the employment or service of the Government of the United States.

17. That the facts stated in this petition are true.

Wherefore, your petitioner asks judgment in its favor against the United States for the sum of One Hundred and Ninety-Five
8 Thousand Dollars ($195,000) as royalty payable to your petitioner in accordance with the terms of said agreement of April 3, 1912, and as compensation for the use of the inventions set forth in said Letters Patent Nos. 1,036,082 and 1,036,080 under Act of Congress of June 25, 1910.

Your petitioner's address is No. 5 Nassau Street, New York, N. Y. The address of its attorney, Norman Johnson, Esq., is No. 5 Nassau Street, New York, N. Y. Electric Boat Company, by Elihu B. Frost, Vice-President. Norman Johnson, Solicitor for Petitioner, No. 5 Nassau Street, New York City. Pennie, Davis & Goldsborough, Counsel for Petitioner, No. 35 Nassau Street, New York City.

9 STATE OF NEW YORK,
County of New York, ss:

Elihu B. Frost, being first duly sworn, deposes and says that he is Vice President of Electric Boat Company, the petitioner and plaintiff named in the foregoing petition; that he has read said petition and knows the contents thereof; that the same is true to his own knowledge save in so far as the averments thereof are stated to be based upon information and belief, and as to those averments he believes it to be true; and that he verily believes that Gregory C. Davison was the original, first and sole inventor of the improvements in Automobile Torpedoes set forth in said Letters Patent No. 1,036,082, and the improvements in Apparatus for Generating Motive Fluid for Automobile Torpedoes set forth in said Letters Patent No. 1,036,080, referred to in said petition. Elihu B. Frost.

Subscribed and sworn to before me this 27th day of July, 1914. Augustus Treadwell, Notary Public, Kings Co., No. 137. Certificate filed in N. Y. County, No. 33.

10 **EXHIBIT "A."**

Shop License.

This agreement, made this 2nd day of April, 1912, by and between the Electric Boat Company, a corporation organized under the laws of the State of New Jersey, party of the first part, and the United States, party of the second part, witnesseth:

That, whereas, the said party of the first part is the owner of the invention known as Steam Generator for Automobile Torpedoes covered by

Application Serial No. 422,175, dated March 9, 1908.
Application Serial No. 486,455, dated March 29, 1909.
Application Serial No. 590,627, dated Nov. 10, 1910.
U. S. Patent Serial No. 980,243, dated Jan. 3, 1911.

And whereas, the said party of the second part is desirous of securing certain manufacturing rights with respect to said invention:

Now, therefore, the said parties hereto have agreed and do hereby agree as follows:

1. The said party of the first part hereby licenses and empowers the said party of the second part to manufacture for and on behalf of the said party of the second part either in its own shops or by

contract in private shops and to use torpedoes equipped with Steam Generator for Automobile Torpedoes covered by

Application Serial No. 422,175, dated March 9, 1908.
Application Serial No. 486,455, dated March 29, 1909.
Application Serial No. 590,627, dated Nov. 10, 1910.
U. S. Patent Serial No. 980,243, dated Jan. 3, 1911.

and any improvements thereon now or hereafter owned or
11 controlled by the party of the first part, subject to the conditions hereinafter named, to the end of the term for which Letters Patent for said invention and any improvements thereon have been or may be granted.

2. The said party of the second part hereby agrees to pay to the said party of the first part in consideration of the license hereby granted a royalty of one thousand dollars ($1,000) for each of the first ten torpedoes equipped with the Steam Generator for Automobile Torpedoes covered by the application for Letters Patent and Letters Patent before mentioned manufactured by the party of the second part under this license, nine hundred dollars ($900) for each of the second ten torpedoes so equipped manufactured under this license by the said party of the second part, and eight hundred dollars ($800) for each additional torpedo so equipped manufactured under this license by the said party of the second part, no royalty to be paid or payable by the said party of the second part to the said party of the first part under this agreement until each such Steam Generator for Automobile Torpedoes shall have been tested and accepted by the said party of the second part.

3. The said party of the first part will at its own expense defend the said party of the second part and hold it harmless against all and every demand or demands of any nature or kind heretofore made or that shall hereafter be made for or on account of the manufacture for its own use by the said party of the second part in its own shops or by contract in private shops or by reason of the adoption or use by said party of the second part of the device covered by the application for Letters Patent and Letters Patent hereinbefore men-
12 tioned, to wit, the Steam Generator for Automobile Torpedoes, or any improvements thereon now or hereafter owned or controlled by said party of the first part.

4. The said party of the second part hereby agrees to make full and true returns to the said party of the first part, on the first day of January each year of the number of Steam Generators and Automobile Torpedoes therewith manufactured under this license during the preceding year.

5. No member of or delegate to Congress, officer of the Navy nor any person holding any office or appointment under the Navy Department is or shall be admitted to any share or part of this contract or to any benefit to arise therefrom.

6. Nothing in this license-agreement shall be held or construed to interfere with or limit in any wise any present or future right of the party of the first part to manufacture or use the said Steam Generator

for Automobile Torpedoes or any improvement or modification thereof and torpedoes equipped therewith for demonstration or other purposes whatsoever or to sell and dispose thereof.

In witness whereof, the said parties hereto have hereunto set their hands and seals the day and year first above written. Electric Boat Company, by Elihu B. Frost, Vice-President. The United
13 States, By Beekman Winthrop, As Acting Secretary of the Navy. Witnesses: H. Taylor. Harry W. Miller, Solicitor, as to Beekman Winthrop, Acting Secretary of the Navy. (Blue Seal Navy Department United States of America.)

14 **II. GENERAL TRAVERSE.**

No demurrer, plea, answer, counterclaim, set-off, claim of damages, demand, or defense in the premises, having been entered on the part of the defendant, a general traverse is entered as provided by Rule 34.

III. HISTORY OF PROCEEDINGS.

On April 3 and 4, 1919, the case was argued and submitted by Mr. Dean S. Edmonds, for the plaintiff, and by Mr. W. D. Eakin, for the defendant.

On June 28, 1919, the Court filed tentative findings of fact and allowed both parties until Sept. 15, 1919 in which to file objection or suggested changes thereto.

On Sept. 15, 1919, the defendant filed a motion for changes in said tentative findings of fact.

On September 16, 1919, the plaintiff filed a motion to amend tentative findings of fact.

On October 24, 1919, the case was argued and submitted on tentative findings of fact by Mr. Dean S. Edmonds, for the plaintiff, and by Mr. W. D. Eakin, for the defendant.

On April 5, 1920, the Court filed findings of fact and conclusion of law and entered judgment in favor of plaintiff, and remanded case for proof of liability, with an opinion by Campbell, Ch. J.

On June 21, 1920, the defendant filed a motion for a new trial.

On October 13, 1920, the defendant's motion for a new trial was argued and submitted by Messrs. J. Edgar Bull and F. L. Emery, for the defendant, and by Mr. Dean S. Edmonds, for the plaintiff.

On November 15, 1920, the Court filed an order allowing in part and overruling in part defendant's motion for a new trial,
15 setting aside and withdrawing conclusion of law, judgment and opinion, and filing a new opinion by Chief Justice Campbell.

On September 29, 1921, on motion made therefor, Messrs, Pennie, Davis, Marvin & Edmonds, were substituted as attorneys of record—Norman Johnson, the former attorney, consenting thereto.

IV. FINAL ARGUMENT AND SUBMISSION OF CASE.

On October 4, 1921, the case was argued and submitted by Mr. Dean S. Edmonds, for the plaintiff, and by Mr. J. Edgar Bull, for the defendant.

V. HISTORY OF FURTHER PROCEEDINGS.

On April 3, 1922, the Court filed findings of fact and conclusion of law dismissing petition and entered judgment against plaintiff for the cost of printing in the sum of $605.34, with a Per curiam opinion.

On May 18, 1922, the plaintiff filed a motion to amend the findings of fact filed April 3, 1922.

On May 25, 1922, the defendant filed a motion to amend and supplement the findings of fact filed April 3, 1922.

16 VI. ORDER OF COURT ENTERED JUNE 26, 1922.

This cause coming on to be heard upon the plaintiff's motion and also upon the defendant's motion to amend findings it is ordered by the Court that each of said motions be allowed in part and overruled in part. The former findings are withdrawn and new findings are this day filed. The petition is dismissed. Opinion Per Curiam. By the Court.

17 VII. FINDINGS OF FACT, CONCLUSION OF LAW, OPINION PER CURIAM, AND EXHIBITS I, II, III TO THE COURT'S FINDINGS. ENTERED JUNE 26, 1922.

This case having been heard by the Court of Claims, the court, upon the evidence, makes the following

Findings of Fact

I.

The plaintiff is a corporation, organized and existing under the laws of the State of New Jersey.

II.

On March 29, 1909, Gregory C. Davison, then an employee of the plaintiff, filed in the United States Patent Office an application, Serial No. 486,455, for letters patent for certain improvements in apparatus for generating motive fluid for automobile torpedoes.

III.

For a number of years immediately prior to January 1, 1908, the said Gregory C. Davison was an assistant inspector of ordnance in the United States Navy, in charge of torpedo experiments and development. On said date of January 1, 1908, some three months after his return from an extended European trip for torpedo investigation for the Government said Davison resigned from the United States service and entered the employ of the plaintiff, having charge of torpedo experimental and development work for the plaintiff. Throughout his work as such experimental officer for the Government, including his European trip, Davison kept private notes upon torpedo development, and when he left the Government service he retained such private notes in his possession.

IV.

The general practice in the propulsion of automobile torpedoes has been to employ compressed air for the motive power, and this agency for propulsion has undergone an evolution through the following
18 stages: First, the use of cold compressed air from a storage chamber located in the torpedo, and thence supplied through a reducing valve to the propelling engine; second, the use of the "inside superheater," consisting of a burner, or heater, located in the compressed-air storage chamber, to heat the air therein during the run of the torpedo; third, the use of the "outside superheater," consisting of a combustion chamber on the low-pressure side of the reducing valve in the conduit for carrying air from the storage chamber to the engine, and so arranged as to have liquid fuel admitted and burned within it to heat the air prior to its admission to the engine; and in recent years a fourth stage, namely, the use of steam in combination with the compressed air and gases of combustion as motive power, the steam being generated and combined with the air and the gases of combustion in a combustion chamber located on the low-pressure side of the reducing valve in the conduit for conveying the air from the storage chamber and arranged to have the air, fuel, and water supplied to it where the fuel and the oxygen in the air are ignited and burned and the water converted into steam by the hot products of the combustion.

The automobile torpedoes used by the United States Navy in 1907 and 1908 were of the type having the "inside superheater," and attained a range of about 3,000 yards. In 1909 the Navy obtained torpedoes which were equipped with the "outside superheater," and attained a range of about 4,000 yards.

By the use in the United States Navy of steam as a part of the motive power, as above described, the range attained has been double that attained with the torpedoes equipped with either the "inside superheater" or the "outside superheater."

V.

One of the chief efforts of those interested in the manufacture and use of torpedoes had been the effort to increase the effective range of this instrument of warfare; and in March, 1908, the attention of the Bureau of Ordnance of the Navy Department was directed to an article in the Revista Maratima Brazileira published in January, 1908, and constituting Exhibit C-14 to these findings of fact, which described the torpedo power plant of the Gesztesy patent constituting Exhibit C-13 to these findings, which power plant provided for the generation and use of steam in combination with compressed air and the gases of combustion for motive power.

On March 26, 1908, this article was forwarded by the Bureau of Ordnance to the E. W. Bliss Company, a commercial firm then manufacturing torpedoes for the Navy, for the company's attention. The Bliss Company on April 4, 1908, returned the article to the bureau with a statement that the company had for some time "had plans on the same general principle as that shown" in the article, and that while it believed there were inherent difficulties against the operation of such a system, it intended at as early a date as possible to make certain tests of it.

On April 17, 1908, the Bureau of Ordnance requested the Bliss Company to inform it of the results of any experiments the company might make with a "superheater of this type," in response to
19 which the company on June 9, 1908, replied that it had as yet made no progress with such experiments, as its testing facilities were so fully occupied with torpedoes under way for the bureau that it could not then conduct any outside experiments, and that it would report to the bureau the results of any experiments it should make.

Beginning in November, 1909, experiments were carried on by the Bureau of Ordnance at the naval torpedo station at Newport for increasing the motive power and range of torpedoes by the use of steam generated by the injection of water into the combustion chamber, where the steam was combined with the compressed air and gases of combustion. In June, 1910, the ordnance engineer in charge of such experimentation officially reported that in view of the limit on the permissable heat on account of the melting or burning of the material, or a weakening of the structure of the mechanism, the only recourse for increasing the run of the torpedo (the air charge being fixed) was by adding to the volume of the air; that the problem therefore resolved itself "into that of injecting or otherwise introducing some liquid (water obviously being most suitable) into the heater space. the liquid by its evaporation absorbing the excessive heat and adding its own volume to the volume of the air," more fuel being burned "to give a higher temperature to evaporate more water to add more volume;" and that the final limit to the possible gain in that direction is fixed by the amount of oxygen in the air-chamber charge which can be consumed in supporting combustion. In his report the ordnance engineer stated:

"The best method of introducing the water has yet to be ascertained, and when that is done, a further increase in the size of the heater will correspondingly increase its capacity. * * * In general the effort is being made to produce a torpedo better than the best for present needs, and as free as possible from structural hindrances to changes that will be necessary in case certain apparently possible improvements are made in the future. The present heater is capable of burning 66 per cent alchol, and it burns 75 per cent alcohol with great steadiness and certainty. For the present and until there is produced a torpedo thoroughly reliable in the functioning of all those details which have nothing to do with the heater, it is proposed to use 75 per cent alcohol for fuel and no injection of water."

And in a letter transmitting this report there was included a statement as follows:

"As will be seen from the description, the basic principle of the new design is the attempt to increase the range of the torpedo by the introduction of some liquid, preferably water, into the superheater pot, the excess heat of the combustion of the alcohol or kerosene used as fuel being utilized to vaporize the liquid and increase the volume. Several methods of vaporizing the liquid have been experimented with, varying from spraying the liquid through minute orifices to a method employing the flash boiler principle, in which the liquid is progressively heated during its progress through a coil boiler until it emerges as steam. These experiments have been in progress since November 1, 1909, until the present time."

Also in 1910, verbal information was received by the Bureau of Ordnance from the Bliss Company with reference to experiments by the company along the same line; and in a letter of October 14, 1910, said company reported to the bureau as follows:

"As the bureau is probably aware, we have designed a new 21-inch torpedo on the general lines of the Mark VI, with a device added which enables us to inject water into the superheater, and materially increase the efficiency. While we have not yet carried our experiments in this direction to a finish, we have already obtained twenty million foot-lbs. of work out of the Mark III, 21-inch flask full of air, against about ten to eleven million which we develop with the standard Mark III torpedo. Of course, with a longer flask, as would be used in a torpedo 21 ft. long, the work done can be still further increased."

VI.

On July 26, 1910, Commander A. L. Norton, the Bureau of Ordnance officer in charge of torpedo work, visited the plaintiff company to confer with the said Gregory C. Davison on the subject of air compressors and gyroscopic control gear, and at that time learned from said Davison somewhat of the progress of certain experimental work by him in developing torpedo motive power by the injection of water into the combustion chamber, but was not shown any of the compo-

nent parts of the apparatus used. Commander Norton at that time requested Davison to take up again the matter of the development of his steam generator, along with other matters of interest to the Bureau of Ordnance.

VII.

Under date of August 8, 1910, plaintiff company wrote the Chief of the Bureau of Ordnance as follows:

"SIR: Referring to the device which we have developed for increasing the range of automobile torpedoes, we beg to submit herewith a proposition whereby the bureau may acquire the rights to said apparatus:

"1. At the present writing no steps have been taken to exploit this apparatus abroad and no information has been given out concerning it. If the United States Government desires to secure exclusive rights to the exclusion of all foreign governments we are prepared to enter into such an arrangement, the terms for which would be submitted upon request. Owing to the fact that the volume of foreign torpedo business is very greatly in excess of the United State business, the price for this exclusive right would have to be very much higher than the price for the United States rights. The price for such exclusive rights would have to be agreed upon in advance subject to the satisfactory demonstration of the apparatus, and the offer would be limited to a period of 30 days after the completion of a successful demonstration.

"2. Assuming that the United States rights only are to be acquired by the Government, we would propose that the acquirement of the rights and payment therefor be made contingent upon the successful demonstration of the guaranteed qualities of the torpedoes fitted with this apparatus. If this demonstration is made upon a converted torpedo, the same is to be loaned to us by the Navy Department, the conversion and tests to be carried out at our own
21 expense, and in the event of a failure to demonstrate the guarantees the torpedo is to be restored to its original condition and returned to the Government without cost. In the event of a successful demonstration the Government will take over the converted torpedo at a price to be agreed upon in advance. The department's option to take over the rights upon terms to be agreed upon in advance of the experiment or loan of torpedo will be limited to a period of three (3) months after the successful demonstration.

"The terms which we are prepared to offer the department now are as follows:

"Cash payment of $100,000.00 on closing the option, with the provision that the department shall pay the following royalties on each torpedo in which the apparatus is used in the future, viz:

"For the first 100 torpedoes, $1,200.00 per torpedo.

"For the second 100 torpedoes, $950.00 per torpedo.

"For the third 100 torpedoes, $750.00 per torpedo.

"For all subsequent torpedoes, $600.00 per torpedo.

"In return for this cash payment and the above royalties we would

grant to the department the right to manufacture the apparatus itself, as well as the right to fit it in torpedoes of any make. The license, however, would not include the right to grant sublicenses to other companies unless the Electric Boat Company should be unable or refuse to accept any orders offered by the department for the manufacture of the appliance or fitting it in torpedoes. Such orders shall allow a reasonable time for the work, and shall be on a basis of reasonable manufacturer's profits plus the agreed royalty. The option and the license to contain a clause specifying that all information, plans, data are to be treated as confidential, and that the department is to take reasonable precautions to enforce this feature, it being expressly understood that no plans or other information shall be shown or given to any corporation, firm, or person engaged or interested in the manufacture or development of torpedoes or torpedo appliances.

"The option is to contain a clause making the license agreement obligatory upon the department in case of a successful demonstration of the guarantees.

"All plans and detailed information with respect to the apparatus together with the converted torpedo are to be furnished to the department at the time the license agreement goes into effect, and the department is to be entitled to all improvements made during the life of the license.

"It is proposed to make the license run fifteen (15) years.

"The license to contain a provision that if in any one year the royalty fails to amount to the sum of $25,000, including the apparatus manufactured by the department and by the Electric Boat Company for the department, it shall be optional with the Electric Boat Company to cancel the license."

VIII.

On September 6, 1910, the Bureau of Ordnance, with a view to determining the merits of the different motive power systems for increasing the range and speed of torpedoes, addressed substantially similar letters to the Bliss Company and the plaintiff company, proposing to each company that it undertake on an experimental basis the construction of an 18-inch torpedo on a fixed price basis for a specified minimum performance of a 4,000-yard run at a speed of 26 knots, with a bonus for excess performance, each company being informed that the torpedo constructed by it would be placed in competition with a torpedo to be submitted by another firm and with torpedoes being developed by the bureau itself. Following correspondence between the bureau and each of said companies relative to price, terms, and conditions, similar contracts were entered into between the bureau and said companies for the production by each company of both an 18-inch and a 21-inch torpedo, the contracts with the plaintiff company being dated January 17 and 23, 1911; and those with the Bliss Company being dated February 16, 1911.

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The Bliss Company completed its 21-inch torpedo in August, 1911; and it was tested in the fall of that year and accepted and paid for by the Government on the basis of having attained a range of 10,000 yards at a speed of 26 knots. The 18-inch torpedo was completed by said company about May, 1912; its performance in the tests was far in excess of the minimum requirements of the contract, and it was accepted and paid for at the contract price.

On January 18, 1912, the Bureau of Ordnance was preparing a contract with the Bliss Company for the manufacture of 50 torpedoes having power plants like that of the 21-inch Bliss torpedo above referred to, and in the month of June, 1912, the Government let contracts to the Bliss Company for the manufacture of 290 torpedoes having similar power plants.

The plaintiff company completed its 18-inch torpedo about October, 1912; but it failed in the tests to meet the minimum requirement of the contract for a range of 4,000 yards, and was therefore not accepted by the Government. The 21-inch torpedo was never completed by the plaintiff company; and, finally, on June 16, 1914, the contracts for said torpedoes were, at said company's request, canceled by the Government without penalty.

IX.

On October 20, 1911, the Electric Boat Company wrote the Bureau of Ordnance a letter reading as follows:

"1. We beg to inform the bureau that we have developed a device which may be applied to any automobile torpedo now in service and which will more than double the range of such torpedo.

"2. We inclose herewith drawing No. C-10227, showing a general arrangement of this device applied to the Whitehead 5.2 m. x 45 cm. torpedo.

"3. In order to apply this system to existing torpedoes, it becomes necessary to increase the length of the torpedo about eight inches.

"4. If applied to the B. L. 5 m. x 45 cm., Mark III torpedo the length would not be increased to more than 5.2 meters.

"5. We have made a number of actual tests with this device and have obtained 150,000 foot-pounds of energy per pound of air. This compares with about 40,000 foot-pounds per pound of air in
23 the B. L. 5 m. x 45 cm., Mark III, and 60,000 foot-pounds per pound of air in the Whitehead 5.2 m. x 45 cm. torpedo.

"6. If the bureau desires us to fit one of its existing torpedoes with this device, we shall undertake to do so after arranging with the bureau for a royalty to be paid on all torpedoes fitted with this device in the future.

"7. Our estimate of time required to modify an existing torpedo is five months, and cost, fifteen hundred dollars ($1,500.00).

"8. We would ask one thousand dollars ($1,000) royalty per torpedo for the first ten torpedoes, nine hundred dollars ($900)) per torpedo for the second ten, and eight hundred dollars ($800) per torpedo for all torpedoes thereafter."

At this time the Government possessed a large number of Whitehead torpedoes of 4,000 yards, and under, range.

Said letter and drawing were transmitted by the bureau to Commander Williams, inspector of ordnance in charge of the torpedo station at Newport, who, under date of October 27, 1911, returned it to the bureau with an indorsement as follows:

"Subject: Holland Torpedo Boat Co.: Rel. device which may be applied to automobile torpedo to double the range.

"1. The blue print forwarded herewith gives no information as to the methods by which the range of the torpedo is to be doubled beyond stating that the device is a steam generator. It is presumable that the device consists of a superheater into which is injected water. The E. W. Bliss Company, proceeding along the same lines, have already a torpedo in the water which indicates the possibility of doubling the range of the torpedoes now in the service. The torpedo station will in a very short time take up actual tank experiments with a new form of superheater which promises to double the range of the torpedo. The Schneider Company and the Whitehead Company are both experimenting with a superheater into which water is injected.

"2. In view of the above it is not considered wise to enter into an agreement with the Electric Boat Company by which the bureau agrees to pay the Electric Boat Company a royalty for the use of a device in torpedoes presumably similar to devices made by other companies, and to one which is in the course of development at the torpedo station, as by that action the bureau would, in the opinion of the torpedo station, possibly involve itself in dispute if not in litigation with the other companies, and would be estopped from further development of its own superheater.

"3. A preferable procedure, the torpedo station believes, would be to place an order with the Electric Boat Company for a number of torpedoes, paying them the same price that the bureau pays the E. W. Bliss Company for torpedoes of equal capabilities, buying the torpedoes simply as commercial articles, and having no question of royalty or patent rights enter into the contract.

"4. As pertinent to this question it is suggested to the bureau that its files will probably be found to contain a description of a superheater into which water is injected, this description being given to the bureau in 1907 or 1908 by a foreign naval attaché."

24 The bureau, on November 2, 1911, returned the letter to Commander Williams with the following endorsement:

"Subject: Holland Torpedo Boat Co.: Rel. device which may be applied to automobile torpedoes to double range.

"1. Returned for further comment.

"2. The proposition submitted by the Electric Boat Company in the attached letter, as understood by the bureau, is in effect as follows:

"That they will take one of the present type of torpedoes, a Mark V Whitehead, or a Mark III, IV, or VI Bliss-Leavitt torpedo, and by the installation of the Davison steam generator and the removal of superheater, practically double the range of the torpedo, provided the torpedo will stand a lengthening of eight inches.

"3. As the inspector of ordnance is no doubt aware, the bureau has contracts with the Electric Boat Company to furnish 2 5.2 m. x 45 cm. and a 21′ x 21″ torpedo of the Davison type, which torpedoes will be run some time this fall or early next spring.

"4. The attached correspondence is in reference to an entirely different proposition and yet connected with that proposition, inasmuch as the steam generating device will be incorporated in the Davidson torpedoes, and the bureau is given to understand that this generator is not in any sense a superheater, that it has been patented, and it is not to conflict with the present superheater rights.

"5. Comment is desired on the advisability of loaning the Electric Boat Company a torpedo of the Mark IV or Mark VI types in order that their device may be installed therein for test, since if it is possible to increase the range of the present four-thousand-yard torpedoes to eight thousand yards, a long-range torpedo could be obtained without much change in the installations for launching them overboard.

"6. Please return."

Commander Williams, in turn, on November 4, 1911, returned the letter to the bureau with the following additional endorsement:

"Subject: Holland Torpedo Boat Company: Rel. device which may be applied to automobile torpedoes to double range.

"1. Returned.

"2. The torpedo station is still of the opinion that it would be unwise to enter into any royalty agreement with the Electric Boat Company in regard to the steam generator device of a torpedo until the details of this device are thoroughly well known and it is clearly established that the device is different from other patented devices of the same nature, and the torpedo stations previous comments were merely to recommend the nonacceptance of the Electric Boat Company's proposition as submitted, without detailed description.

"3. The torpedo station can see no objection to loaning the Electric Boat Company a torpedo of the Mark IV or Mark VI type in order that this device may be installed therein for test, and recommends that a Mark VI torpedo be so loaned to be fitted and after being fitted that the torpedo be returned to the torpedo station to be tested there under the supervision of a representative of the Electric Boat Company."

As early as September 24, 1911, the Government had, on the testing range at Sag Harbor, the Bliss 21-inch torpedo, referred to in finding VIII, which had made a run of over 9,500 yards.

25 X.

On November 9, 1911, Admiral Twining, Chief of the Bureau of Ordinance, wrote the Electric Boat Company as follows:

"1. The bureau acknowledges the receipt of your letter of October 20, 1911, signed by your Mr. G. C. Davison, forwarding drawings C-10227, general arrangement of device for increasing range of Whitehead 5.2 m. x 45 cm. torpedoes.

"2. The bureau thanks you for having submitted this proposition to it for its consideration.

"3. The Bureau of Ordnance will be pleased to furnish you two 5.2 m. x 45 cm. Mark V Whitehead torpedoes, and to make a contract for installing therein your device at a total cost of $1,500 each. These torpedoes to be ready for demonstration at the naval torpedo station under the supervision of a representative of the Electric Boat Company.

"4. Referring to the matter of royalties, the bureau will have drawn up an agreement by which it will agree to pay a royalty of $1,000 per torpedo for the first ten (10) converted, nine hundred dollars ($900) per torpedo for the second ten (10) converted, and eight hundred dollars ($800) per torpedo for all torpedoes converted thereafter, with the distinct understanding, however, that no royalty is to be paid for the converting of the two torpedoes referred to above, the total cost of $1,500 each covering royalties and the cost of conversion, together with any other cost that may be incurred during the demonstration.

"5. In addition, the bureau will require that the two converted Whitehead torpedoes, referred to above, in which you have installed your device, shall make an increased range of at least fifty per cent of their present ranges (a total of 6,000 yards) on their demonstration at the naval torpedo station, it being understood that the Electric Boat Company believes it is capable of increasing the range to one hundred per cent of the present range (a total of 8,000 yards). This requirement of the bureau of fifty per cent increased range is the minimum that the bureau will consider as the increase for completion of contract for the conversion of the two torpedoes submitted for test and demonstration."

"6. If this arrangement be agreeable to the Electric Boat Company, please so inform the bureau, in order that a requisition may be prepared for the converting of two 5.2 m. x 45 cm. Whitehead Mark V torpedoes at a total cost of three thousand dollars ($3,000), and that an agreement may be drawn up for signature by the Navy Department and the Electric Boat Company in regard to the royalty to be paid for any torpedoes that may be converted hereafter, namely, at the rate of $1,000 per torpedo for the first ten torpedoes converted, $900 per torpedo for the second ten torpedoes converted, and $800 per torpedo for all torpedoes converted thereafter.

"7. An early reply will be appreciated."

On December 6, 1911, the Electric Boat Company replied to this letter as follows:

"Referring to the bureau's letter No. 656/79-80-81 (23712/2) of November 9, 1911, relative to the conversion of two White-
26 head 5.2 m. x 45 cm. torpedoes by the introduction of our device for increasing the range:

"1. The terms mentioned in the bureau's letter will be satisfactory to us.

"2. We are ready to begin work on the two torpedoes as soon as they are received.

"3. As regards paragraph 6 of the bureau's letter, it is our understanding that the royalty will apply not only to torpedoes which may hereafter be converted but also to torpedoes which the Government may build at its own works and in which the device in question is to be used."

On December 13, 1911, the Bureau of Ordnance wrote the Electric Boat Company as follows:

"Referring to your letter of December 6, 1911, relative to the conversion of two (2) Whitehead 5.2 m. x 45 cm. torpedoes by the introduction of your device for increasing the range:

"1. You are informed that the bureau has this day made out a requisition for the conversion of two (2) 5.2 m. x 45 cm. Whitehead torpedoes by the Electric Boat Company at a total cost of fifteen hundred dollars ($1,500) each, including the necessary demonstration runs at the naval torpedo station.

"2. In connection therewith the bureau is forwarding a blank shop license, or agreement, and requests that you will fill in the name of your steam-generating device and the number of the letters patent in the appropriate blanks, in order that a complete agreement may be made up and forwarded for your signature."

On December 16, 1911, the Electric Boat Company wrote the Chief of the Bureau of Ordnance as follows:

Subject: Increasing range of torpedoes.

"SIR: We beg to acknowledge receipt of your No. 23712/2 (G) of the 13th instant, forwarding draft of shop license agreement relative to our device for increasing the range of automobile torpedoes. The following is a list of the United States patents and applications whereby this device is protected:

"Application Serial No. 422,175, dated Mar. 9, 1908.

"Application Serial No. 486,455, dated Mar. 29, 1909.

"Application Serial No. 590,627, dated Nov. 10, 1910.

"U. S. Patent No. 980,243, dated Jan. 3, 1911.

"You will note that three of these applications have not yet been issued. A number of claims, however, have already been allowed under each of these applications, and delay in issuing the patents is due to argument now pending in relation to certain claims which have been rejected. The protection afforded, however, is the same as if the patents have been issued.

"We return herewith copy of draft of shop license."

On January 9, 1912, the Chief of Bureau of Ordnance replied as follows:

"1. The bureau is forwarding herewith five copies of agreement between the Electric Boat Company and the United States for the use by the United States of the device known as "Steam Generator for Automobile Torpedoes."

"2. Please have this agreement executed on the part of the Electric Boat Company by the proper responsible officials, and re-
27 turn the same to the bureau at your earliest convenience, in

order that it may be executed by the proper officials of the Navy Department.

"3. When so executed, a copy will be returned to the Electric Boat Company."

On January 12, 1912, the Electric Boat Company, in response, wrote the Bureau of Ordnance as follows:

"We inclose to you herewith five (5) copies of agreement between the Electric Boat Company and the United States for use of our device known as steam generator for automobile torpedoes which have been duly executed by this company.

"Will you kindly have these agreements executed on behalf of the United States Government, and return to us copy for our files at your convenience, and oblige."

The said agreement was executed by the plaintiff company and the Acting Secretary of the Navy under date of April 2, 1912, and was as follows:

Shop License.

"This agreement, made this 2d day of April, 1912, by and between the Electric Boat Company, a corporation organized under the laws of the State of New Jersey, party of the first part, and the United States, party of the second part, witnesseth:

"That, whereas the said party of the first part is the owner of the invention known as Steam Generator for Automobile Torpedoes covered by application Serial No. 422,175, dated March 9, 1908; application Serial No. 486,455, dated March 29, 1909; application Serial No. 590,627, dated November 10, 1910; U. S. Patent Serial No. 980,243, dated January 3, 1911.

"And whereas the said party of the second part is desirous of securing certain manufacturing rights with respect to said invention:

"Now, therefore, the said parties hereto have agreed and do hereby agree as follows:

"1. The said party of the first part hereby licenses and empowers the said party of the second part to manufacture for and on behalf of the said party of the second part either in its own shops or by contract in private shops and to use torpedoes equipped with Steam Generator for Automobile Torpedoes covered by application Serial No. 422,175, dated March 9, 1908; application Serial No. 486,455, dated March 29, 1909; application Serial No. 590,627, dated November 10, 1910; U. S. Patent Serial No. 980,243, dated January 3, 1911, and any improvements thereon now or hereafter owned or controlled by the party of the first part, subject to the conditions hereinafter named, to the end of the term for which letters patent for said invention and any improvement thereon have been or may be granted.

"2. The said party of the second part hereby agrees to pay to the said party of the first part in consideration of the license hereby granted a royalty of one thousand dollars ($1,000) for each of the first ten torpedoes equipped with the Steam Generator for Automobile Torpedoes covered by the application for letters patent and letters patent before mentioned manufactured by the party of the second

part under this license; nine hundred dollars ($900) for each of the second ten torpedoes so equipped manufactured under this license by the said party of the second part; and eight hundred
28 dollars ($800) for each additional torpedo so equipped manufactured under this license by the said party of the second part; no royalty to be paid or payable by the said party of the second part to the said party of the first part under this agreement until each such Steam Generator for Automobile Torpedoes shall have been tested and accepted by the said party of the second part.

"3. The said party of the first part will at its own expense defend the said party of the second part and hold it harmless against all and every demand or demands of any nature or kind heretofore made or that shall hereafter be made for or on account of the manufacture for its own use by the said party of the second part in its own shops or by contract in private shops or by reason of the adoption or use by said party of the second part of the device covered by the application for letters patent and letters patent hereinbefore mentioned—to wit, the Steam Generator for Automobile Torpedoes, or any improvements thereon now or hereafter owned or controlled by said party of the first part.

"4. The said party of the second part hereby agrees to make full and true returns to the said party of the first part, on the first day of January each year, of the number of Steam Generators and Automobile Torpedoes therewith manufacted under this license during the preceding year.

"5. No Member of or Delegate to Congress, officer of the Navy, nor any person holding any office or appointment under the Navy Department is or shall be admitted to any share or part of this contract or to any benefit to arise therefrom.

"6. Nothing in this license agreement shall be held or construed to interfere with or limit in any wise any present or future right of the party of the first part to manufacture or use the said Steam Generator for Automobile Torpedoes or any improvement or modification thereof and torpedoes equipped therewith for demonstration or other purposes whatsoever or to sell and dispose thereof.

"In witness whereof, the said parties hereto have hereunto set their hands and seals the day and year first above written."

The patent and applications for patent referred to in said agreement were all upon inventions of the said Gregory C. Davidson, by whom they had been assigned to the plaintiff.

Said patent and patent applications were not seen by the Bureau of Ordnance prior to the execution of said agreement of April 2, 1912.

XI.

Pursuant to the plaintiff's proposition of October 20, 1911, shown by Finding IX, for the equipment of an existing Government torpedo with the plaintiff company's said device plaintiff proceeded under contract with the Bureau of Ordnance to so equip two White-

head Government torpedoes, and in November, 1912, sent them to the Government torpedo station at Newport for their tests to determine whether they complied with the contract terms, the minimum range requirement of which was 6,000 yards, a 50 per cent increase of their original range. After a long period of experiments at the torpedo station, one of these torpedoes exceeded on one
29 occasion the minimum run of 6,000 yards required for acceptance; and on October 6, 1913, the company's bill for $3,000 for the conversion of said torpedoes was approved by the Bureau of Ordnance and was thereafter paid.

On September 27, 1913, the naval torpedo board reported on these torpedoes as follows:

"In reference to paragraph 1(*f*) of the precept, the board is of the opinion that—notwithstanding the fact that one Whitehead torpedo, fitted with the steam-generating device, did, on one occasion, make a run of 6,000 yards at 27 knots after a long period of experiments at the torpedo station—the reliability of this form of steam generator has not been established, and, due to the use of salt water, there are grave doubts as to the practicability of this device as at present fitted for service use. It is recommended that no steps be taken toward the conversion of service Whitehead torpedoes into steam torpedoes of this modification until further investigation by the torpedo station has removed these doubts."

The form and character of the company's said device with which these two Whitehead torpedoes were equipped are shown by the drawing and description constituting Exhibit I of the appendix to these findings of fact, which appendix is by reference made a part of these findings of fact.

XII.

On August 20, 1912, there were granted to the plaintiff company as assignee of the said Gregory C. Davison, upon said Davison's application, Serial No. 486,455, United States Letters Patent No. 1,036,080, which are set out as Exhibit II in the appendix to these findings.

The proceedings in the Patent Office upon said application prior to the granting of said letters patent are shown in the certified copy of file wrapper and contents relating thereto, which copy accompanies, and is by this reference thereto made a part of, these findings as Exhibit A.

XIII.

Since the granting of said Letters Patent No. 1,036,080 to the plaintiff on August 20, 1912, the United States has purchased from other parties than the plaintiff, and has used, automobile torpedoes equipped with mechanism for storing, producing, and transmitting motive power, constructed and operating as shown and described by the drawing and description of operation constituting Exhibit III of the appendix to these findings of fact.

The character and mode of operation of said mechanism is further shown by the blue prints of drawings and the model of reducing valve accompanying, and hereby made a part of these findings of fact as Exhibits B-1, B-2, B-3, and B-4, respectively.

Said mechanism, except for slight improvements and modifications, is a practical duplicate of that of the Bliss Company torpedo, built under the said contract of February 6, 1911, referred to in Finding VIII, and which was tested and accepted by the Government in the fall of 1911.

30 XIV.

The following patents and publication show the development and state of the art to which the plaintiff's said patent No. 1,036,080 relates:

1. United States patent to Maxim, No. 641,787, of January 23, 1900.

2. United States patent to Leavitt, No. 693,871, of February 25, 1902.

3. United States patent to Leavitt, No. 693,872, of February 25, 1902.

4. British patent to Sodeau, No. 3,495, of August 12, 1905.

5. British patent to De Ferranti, No. 9,496, of 1904, published August 17, 1905.

6. United States patent to De Ferranti, No. 925,889, of June 22, 1909; application filed April 17, 1905.

7. United States patent to Sodeau, No. 835,262, of November 6, 1906.

8. British patent to Sodeau, No. 15,997, of 1906; published July 17, 1907.

9. United States patent to Sodeau, No. 944,975, of December 28, 1909; application filed March 25, 1907.

10. British patent to Sodeau, No. 6,081, of 1907; published April 23, 1908.

11. United States patent to Sodeau, No. 964,574, of July 19, 1910; application filed January 27, 1908.

12. British patent to Gesztesy, No. 18,241, of 1908; published March 3, 1909.

13. French patent to Gesztesy, No. 393,324; published December 19, 1908.

14. Revista Maritima Braziliera, published January, 1908.

15. United States patent to Davison, No. 1,036,082, of August 20, 1912; application filed March 19, 1908.

Copies of said patents and publication accompany, and are by this reference thereto made a part of, these findings of fact as Exhibits C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, and C-15, respectively.

XV.

The devices of the plaintiff's said Letters Patent No. 1,036,080 which are claimed by the plaintiff to have been manufactured or

used by the United States, and for the manufacture or use of which the plaintiff seeks a recovery in this cause, are the devices of claims 1, 5, and 13 of said letters patent.

It does not appear from the evidence that any of said devices or inventions have been manufactured or used by the United States.

Conclusion of Law.

Upon the foregoing findings of fact, the court decides, as a conclusion of law, that the plaintiff is not entitled to recover, and its petition is therefore dismissed.

31 Judgment is rendered against the plaintiff in favor of the United States for the cost of printing the record in this cause, the amount thereof to be entered by the clerk and collected by him according to law.

Opinion.

PER CURIAM: The defendant's motion for a new trial was allowed and additional evidence has been adduced. The findings of fact have been amended in important particulars.

The action is upon an alleged express contract. The facts show the circumstances under which this contract was made, and, at most, it can be said to be a shop license covering the use of the particular device in torpedoes covered by Davison's patents or applications. Other patents in use and the state of the art convince us that other patentees than Davison, and the Government as well, were experimenting with torpedoes having steam generators at and before the time of the shop license contract. Not only were experiments being made but the Sodeau and other patents in evidence disclose a steam generator. The question resolves itself into whether the Government used the plaintiff's device or something covered by one of the claims in its patents. We are of the opinion it did not. And if there be any doubt on this issue the court is of opinion that the shop license should not be so liberally construed as to prevent the Government showing the exact nature of the device it used and its difference from that covered by the plaintiff's claims.

The petition will be dismissed, and it is so ordered.

32 **APPENDIX.**

EXHIBIT I.

"Operation of Steam Generating Plant.

"When the starting lever and water tripper are thrown back, the air passes in the usual manner from the air flask through the stop and starting valves to the main reducing valve fig. 1. This valve does not open at first, being held closed by a light spring, and the high-pressure air continues through the pipe *a* to a small auxiliary

reducing valve fig. 2, which is generally set by spring *b* for a constant starting pressure of 150 pounds. This starting air passes by way of pipe *c* through the generator fig. 3 to the engine fig. 4, starting the same. The water pump fig. 5 being directly driven by the engine crank shaft through an extension shaft at *d* then draws the water from the sea through the priming tube *e* and discharges into the combined water regulator and pump air chamber fig. 6. From there the water passes through the port *f* in the check valve support fig. 7 by way of pipe *g* to the equalizing valve fig. 8 and from there through pipe *h* to the top side of the flexible diaphragm *i* in the main reducing valve fig. 1.

"The equalizing valve being held open by a light spring *j* on top of the flexible diaphragm *k* and by the starting air pressure through pipe *l* also allows the water to pass into check valve support fig. 7 by way of pipe *m* and from there through check valves *n* and *o* to fuel tank fig. 9 through lead *p* and to the generator fig. 3 through lead *q*. A small pipe *r* also carries the water to the tripping mechanism of the igniter *s*. In this pipe the delay pot *t* is placed.

"The fuel by the pressure of the water is forced out through pipe *u* and check valve *v* to the burner *x* where it is atomized by the starting air. At that moment the water acting on a diaphragm in the igniter *s* trips the firing pin and fires the cartridges, igniting the mixture in the generator pot. Meanwhile the water which entered
33 the generator through pipe *q* has filled the water jacket *y* and returned through the return pipe *z* to the bottom fitting a^1. From there it passes through a number of small holes b^1 in the neck of the lining c^1 into the flame and is instantly converted into steam, which is carried to the engine by way of pipe d^1. As soon as the steam replaces the cold starting air, the engine speeds up, the pump furnishes additional water pressure, which throws the main reducing valve open and the whole system works at its set pressure. This pressure is varied to any desired amount by means of water-regulator spring e^1, and the excess water passes out through overflow valve f^1 to the sea.

"The office of the equalizing valve is to correct any effect on air, water, and fuel due to any error in the main reducing valve.

"The check valves prevent back firing, when the ignition takes place, and also stop fuel from filling generator pot before ignition. These valves should be examined whenever the torpedo is broken down for overhauling of the engine and be kept free from foreign matter, that may prevent their function.

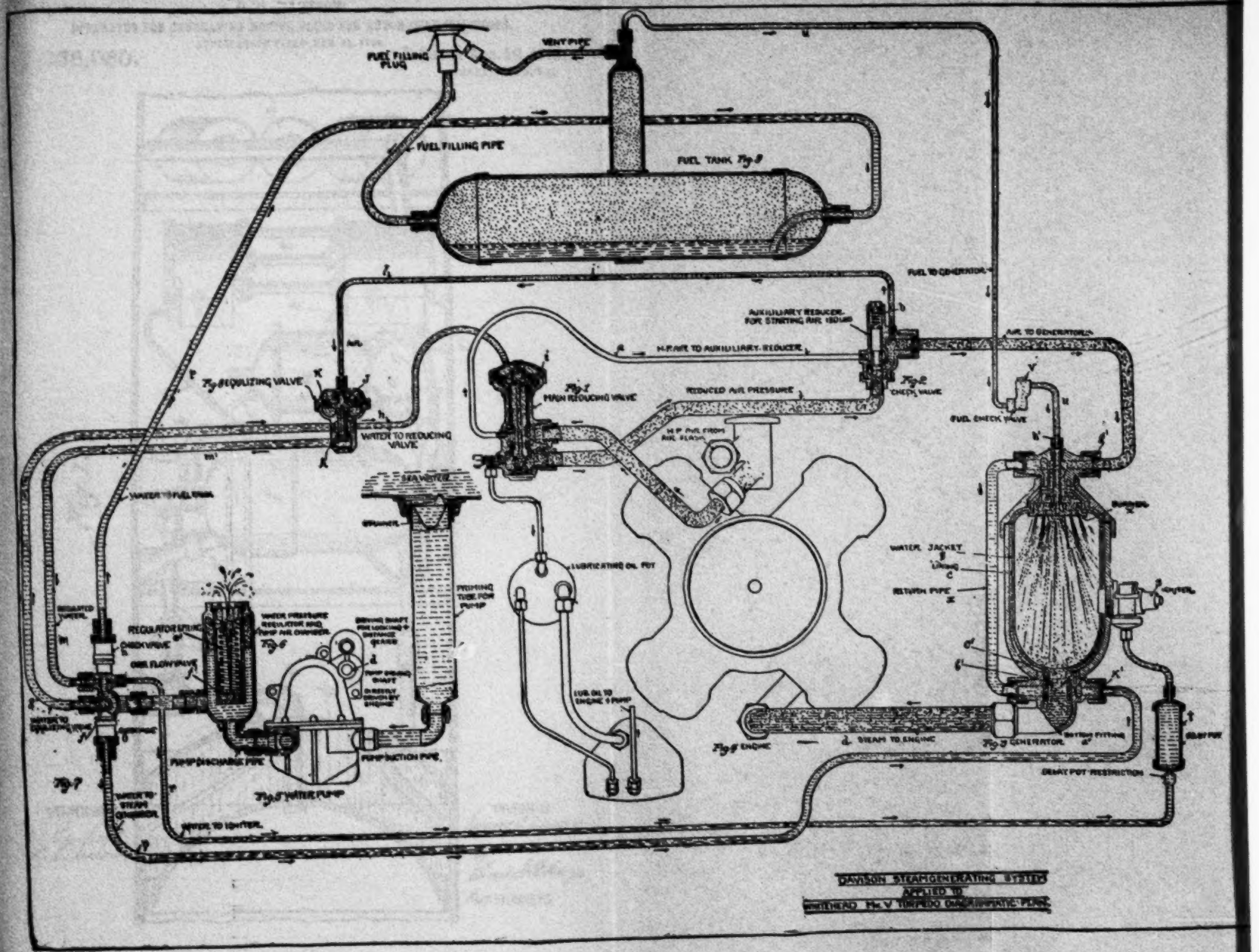
"When preparing the torpedo for a run the fuel tank is filled through filling plug l^1. Pipe m^1 serves as a vent. Two cartridges are screwed into this igniter *s* and the regular spring e^1 is set for the desired pressure.

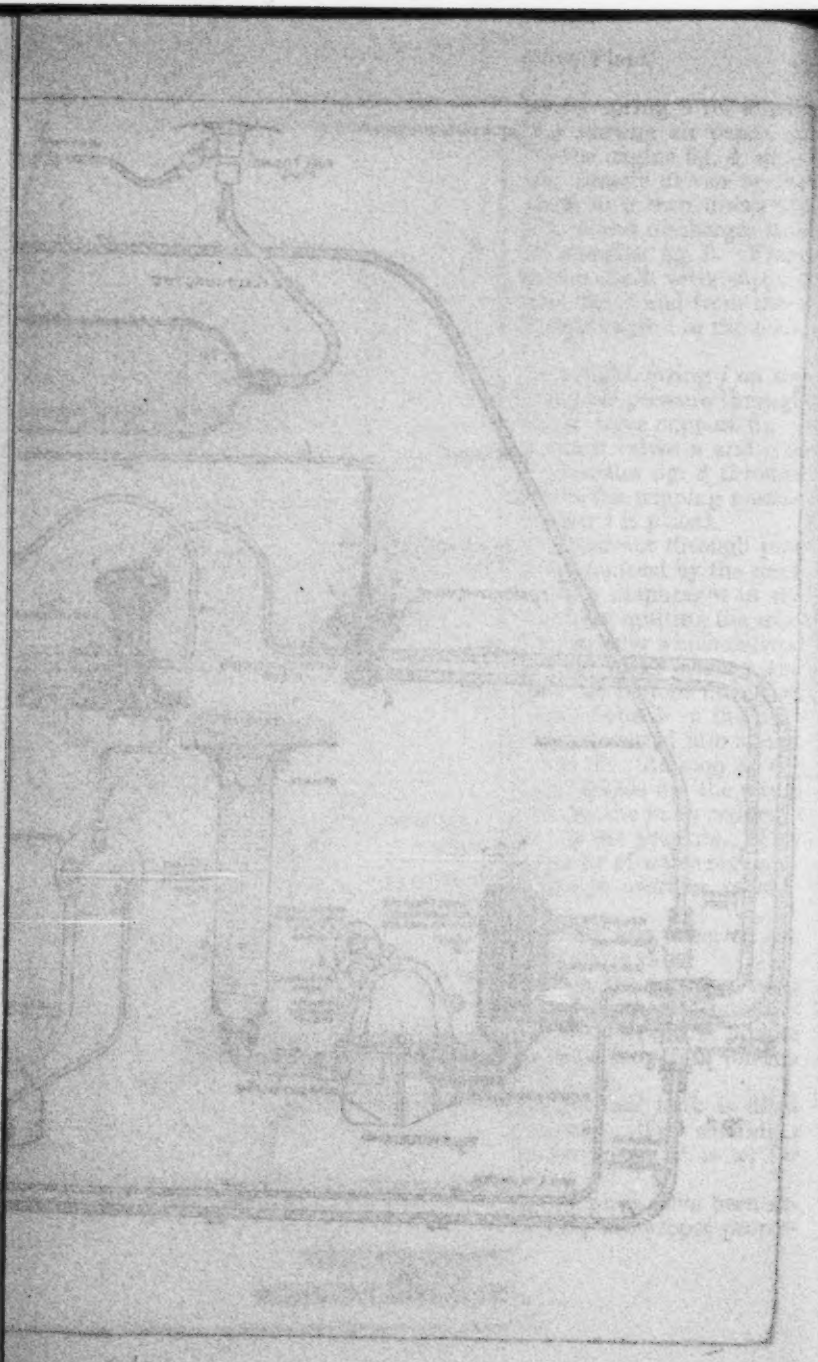
"A set of restrictions for air, water, and fuel pipes have been arrived at experimentally. These restrictions keep the proper proportions of air, fuel, and water and are:

"For air, 0."375 diameter—located at g^1.

"For fuel, 0."041 diameter—located at h^1.

"For water, 0."09 diameter—located at k^1.


FUEL FILLING PLUG
VENT PIPE
FUEL FILLING PIPE
FUEL TANK Fig 9
FUEL TO GENERATOR
AUXILIARY REDUCER FOR STARTING AIR (SEE)
AIR TO GENERATOR
H.P. AIR TO AUXILIARY REDUCER
Fig 10 EQUILIZING VALVE
Fig 1 HIGH REDUCING VALVE
REDUCED AIR PRESSURE
Fig 2 CHECK VALVE
FUEL CHECK VALVE
WATER TO REDUCING VALVE
H.P. FUEL FROM AIR FLASK
SEA WATER
WATER JACKET
LINING
RETURN PIPE
LUBRICATING OIL POT
PRIMING TUBE FOR PUMP
REGULATOR SPRING
CHECK VALVE
WATER PRESSURE REGULATOR AND PUMP AIR CHAMBER Fig 6
DRIVING SHAFT FOR LOCKING & STARTING GEARS
PUMP DRIVING SHAFT DIRECTLY DRIVEN BY ENGINE
LUB. OIL TO ENGINE & PUMP
PUMP DISCHARGE PIPE
PUMP SUCTION PIPE
Fig 5 WATER PUMP
Fig 8 ENGINE
STEAM TO ENGINE
Fig 3 GENERATOR
BOTTOM FITTING
DRAIN POT RESTRICTION
WATER TO STEAM CHAMBER
WATER TO IGNITER
DAVISON STEAM GENERATING SYSTEM
APPLIED TO
WHITEHEAD Mk V TORPEDO EXPERIMENTAL PLANT



G. C. DAVISON.

APPARATUS FOR GENERATING MOTIVE FLUID FOR AUTOMOBILE TORPEDOES.

APPLICATION FILED MAR. 30, 1909.

1,036,080.

Patented Aug. 20, 1912.

2 SHEETS—SHEET 1.

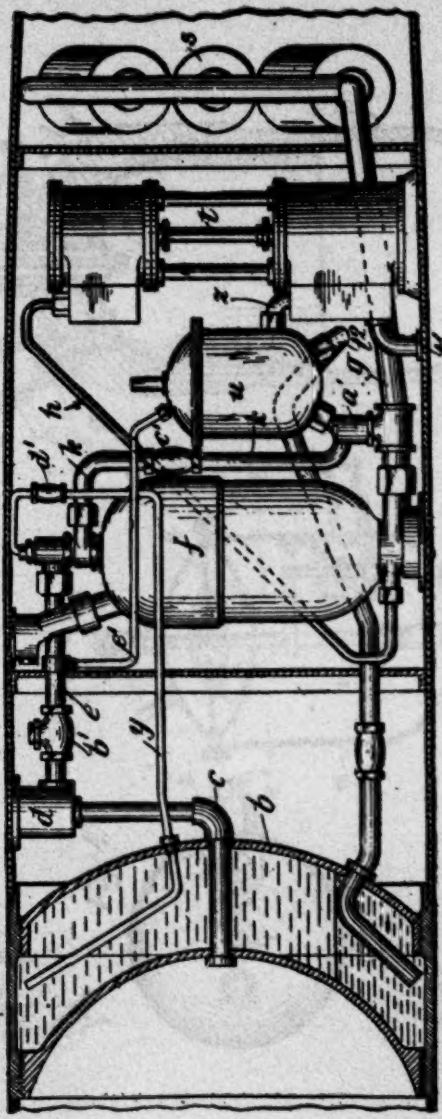


Fig. 1.

WITNESSES:

L. B. Penfield

L. C. Barlow

INVENTOR

Gregory C. Davison

By Thomas G. Oakley

his ATTORNEYS

G. C. DAVISON.

APPARATUS FOR GENERATING MOTIVE FLUID FOR AUTOMOBILE TORPEDOES.

APPLICATION FILED MAR. 29, 1909.

1,036,080.

Patented Aug. 20, 1912.

3 SHEETS—SHEET 2.

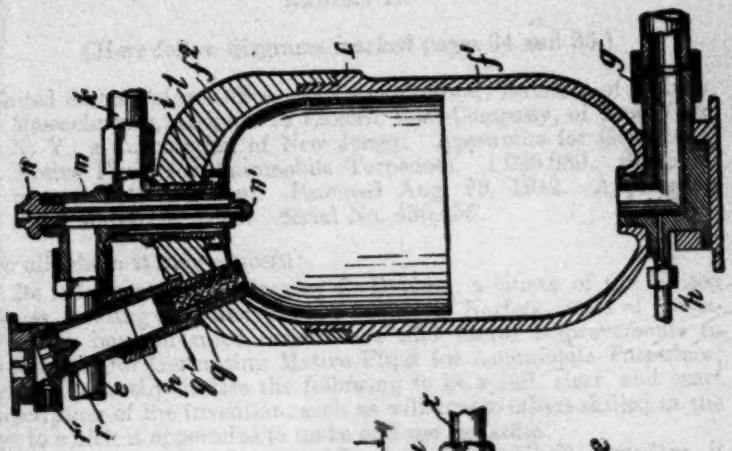


Fig. 2.

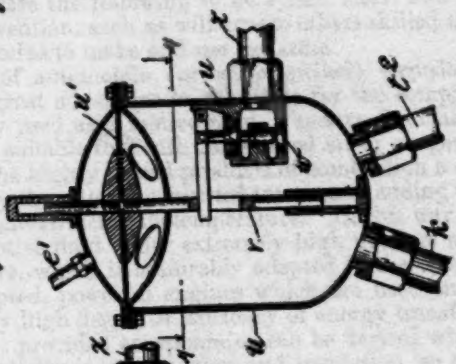


Fig. 3.

Fig. 4.

WITNESSES:

L. B. Bamfield

L. H. Parlin

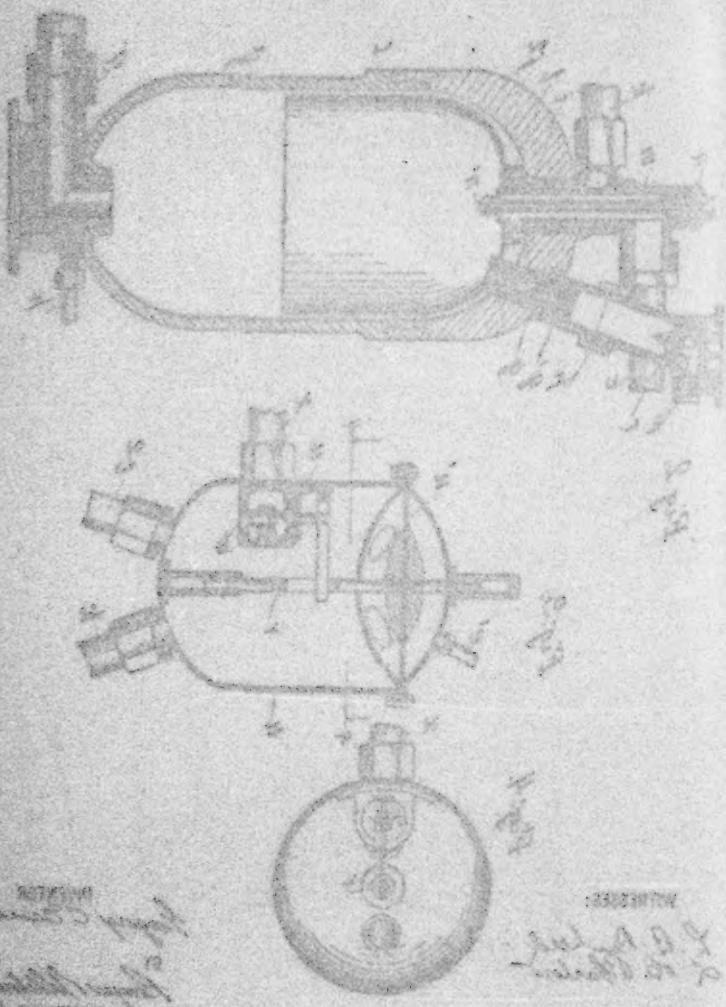
INVENTOR

Gregory C. Davison

BY

Bruce & Hildebrand

his ATTORNEYS



"For 50 horsepower or about 28.5 knots speed.
"The working pressures are:
"For water, 340 pounds.
"For air, 325 pounds.
"For steam, 300 pounds."

EXHIBIT II.

(Here follow diagrams marked pages 34 and 35.)

United States Patent Office. Gregory Caldwell Davison, of Quincy, Massachusetts, Assignor to Electric Boat Company, of New York, N. Y., a Corporation of New Jersey. Apparatus for Generating Motive Fluid for Automobile Torpedoes. 1,036,080. Specification of Letters Patent. Patented Aug. 20, 1912. Application Filed March 29, 1909. Serial No. 486,455.

To all whom it may concern:

Be it known that I, Gregory C. Davison, a citizen of the United States, residing at Quincy, in the county of Norfolk, State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Generating Motive Fluid for Automobile Torpedoes; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In the operation of automobile (or self-propelled) torpedoes, it would be of great advantage to substitute for the compressed
36 air commonly used as a motive fluid, a motive fluid derived by burning a suitable fuel with compressed air or oxygen and then injecting into the highly heated products of combustion a quantity of water, whereby the water is converted into steam, adding to the volume of the fluid and reducing its temperature. In this way there may be formed a motive fluid under extremely high pressure and at moderate temperature, which is admirably adapted to the operation of the light, high-speed, powerful engines which are used on such torpedoes; and a very high degree of efficiency of energy transformation may be secured; provided an apparatus can be devised which is of the requisite simplicity in construction and regulation, so that it may be used without danger and with the assurance that it will be in operative condition whenever it may be called upon to do its work.

It is the object of the present invention to provide an apparatus suitable for that purpose, and the particular nature and principles of operation of the means employed to that end will be understood from a consideration of the following description and the accompanying drawings.

In the drawings, Figure 1 is a central vertical section of a portion of a torpedo showing the apparatus of my invention in elevation. Fig. 2 is a central vertical section of the generator in which the motive fluid is produced; Fig. 3 is a central vertical section of the regulator, and Fig. 4 is a sectional plan of the same on the line 4—4 of Fig. 3.

The oxygen-carrier, preferably air or oxygen, under pressure, is contained in a tank *a*, which, in the construction illustrated, is formed by partitioning off a portion of the body of the torpedo in the customary way; and the fuel is contained in a tank *b*, which is likewise formed by partitioning off a portion of the body of the torpedo. A take-off pipe *c* leads from the tank *a* to and through reducing valve *d*, which is of the type commonly used in torpedoes of this class and is adapted to be opened automatically when the torpedo is launched. From here the oxygen-carrier flows at a reduced pressure through the pipe *e* to the generator *f*, within which it is intended that the mixed fuel and oxygen-carrier shall be burned, and charged with water vapor. The construction of the generator *f* will be understood from Fig. 2, from which it will be seen that the generator comprises a strong cylindrical tank with rounded ends made in two parts *f'* and *f²*. The lower portion *f'* has tapped into it at the bottom the take-off pipe *g* leading to the engine, and the take-off pipe *h* of considerably smaller capacity leading to the pump. The upper part *f²* of the generator has tapped into it centrally at the top the compound nozzle. This nozzle comprises an outer threaded sleeve *i*, into which the water pipe *k* leads, and which terminates within the cylinder in a spraying-head *l*, having spray-holes adapted to discharge the water tangentially against the upper end of the cylinder to set up a circumferential or whirling motion; an intermediate sleeve *m* with which is connected the pipe *e* containing the oxygen-carrier; and a central nozzle *n* for the fuel, said nozzle *n* terminating in a rounded head *n'* having spray-holes as shown. Secured to the water spray-head *l* and separating the water spray from the fuel and oxygen-carrier is the dome-shaped hood *o* extending well down into the body of the cylinder, the object of the
37 hood being to prevent the injection of water into the mixed fuel and oxygen-carrier before the combustion is complete. It will be understood that the water sprayed from the head *l* will flow down over the heated hood *o* and the water vapor will mix with the products of combustion in the lower portion of the generating chamber. For starting combustion within the generator I provide a device which is automatically actuated as soon as the oxygen-carrier under pressure is admitted into the generating chamber. For this purpose, I have adopted a known construction of ignition device and have so located it that it is in communication with the generating chamber at the upper portion of the hood *o* in proximity to the compound nozzle. This device comprises a receptacle *p*, in which slides a fuse carrier containing an ignition fuse *q* and carrying a percussion cap *q'*, and capable of sliding up the bore of the receptacle *p* into contact with the firing projection *r*. This firing projection has a central passage for the escape of the air within receptacle *p* when the ignition fuse rises therein, such air passing through the central passage in firing projection *r* and through the spring-pressed check-valve *r'*. Upon admission of the oxygen-carrier under pressure to the generating chamber *f* through the pipe *c* and sleeve *m* the fuse-carrier is forced up the bore of receptacle *p* until percussion cap *q'* strikes firing projection *r* and the fuse is ignited.

A slow burning fuse is preferably used so that the combustible mixture which has formed in the generating chamber will surely be ignited. The manner in which the fuel and water are fed to the generating chamber will be further described hereafter.

From the generating chamber the products of combustion are led, on the one hand, through the pipe *g* to the engines *s*, and on the other hand, through the pipe *h* to the pump *t*. This pump is connected with the water at *t'*, and with the regulator *u* at *x*. The construction of this regulator will be understood from Figs. 3 and 4, from which it will be seen that it comprises a casing divided into an upper and lower chamber by a flexible diaphragm *u'*, which diaphragm carries an adjustable slotted stem *v* actuating the double-seated balanced valve *w*, which controls the inlet passage from the pipe *x* leading from the delivery side of the pump. Into the lower portion of the lower chamber of the regulator is also tapped the outlet pipe t^2 leading to the lower portion of the full tank *b* and the outlet pipe *k* leading to the water nozzle. Into the upper part of the regulator above the flexible diaphragm is tapped the pipe *e'* branching from the pipe *e* and containing the oxygen-carrier under pressure. From the upper part of the fuel tank *b* there extends to the fuel nozzle *n* a fuel pipe *y*.

With this construction and arrangement of parts the pressure of the oxygen-carrier in the pipe *e* on the low pressure side of the reducing valve *d* controls absolutely the pressure on the fuel and the pressure on the water supply to the generating chamber, so that the oxygen-carrier, the fuel and the water are fed always at a predetermined pressure to the generating chamber, and if, for any reason, the supply of oxygen-carrier is cut off or exhausted, the supply of fuel and water to the generating chamber will cease at once, while, as long as there is a supply of oxygen-carrier under pressure and the flow of water into the regulator chamber is not interrupted, the supply of fuel and water to the generating chamber will continue
38 under proper control. Furthermore, by this arrangement the fuel in the fuel tank, as it is withdrawn, is replaced by water, which, of course, remains at the bottom of the tank. This prevents a possibility of the admission of air or oxygen into the fuel tank and the formation therein of an explosive mixture. But a single pump is necessary to feed both the fuel and the water and it is made certain that the fuel and the water will be fed under the same pressure and will both be controlled by the pressure of the oxygen-carrier. This dependence of the fuel supply upon the water supply, and their mutual dependence upon the single pump and the pressure of the oxygen-carrier, is of further advantage in that it is impossible that the water supply should be stopped and the fuel supply continued, thereby creating unduly high temperatures in the generating chamber and engine. Furthermore, it will be observed, the arrangement is such, that if, for any reason, such as the breaking down of the water pump, the flow of water into the regulator chamber is interrupted, the supply of fuel will immediately cease, thus bringing the combustion to an end and preventing unduly high

temperatures; but, nevertheless, the air or oxygen under pressure will continue to flow from the storage tank through the combusion chamber to the engine, and the torpedo will continue to be driven until the supply of oxygen-carrier under pressure is exhausted.

The operation of the system as a whole is as follows: When the torpedo is launched the valve *d* is opened automatically and the oxygen-carrier at the predetermined pressure is admitted to the upper portion of the generating chamber through the pipe *m*. The pressure thus produced in the generating chamber forces the fuse-carrier up the bore of receptacle *p* against the firing projection and ignites the fuse. The fuse contains a slow burning composition preferably one which will burn for several seconds, and before it is burned out, the pump, actuated initially by the oxygen-carrier passing through pipe *h*, will force fuel through the nozzle *n* into the generator, there forming an explosive or combustible mixture which will be ignited by the fuse. At the same time, or substantially the same time, that the fuel is admitted, jets of water will be thrown with a circumferential or whirling motion from the sprayer head *l* into the space between the hood *o* and the body of the generator, and as the hood heats up and the hot products of combustion accumulate the water will be vaporized and mixed with the products of combustion, but by reason of the interposition of the hood *o* the combustion will be complete before the mixture takes place so that the water can not interfere with the combustion. The mixed products of combustion and water vapor in the lower portion of the generator pass through the pipe *g* to the engine and through the pipe *b* to the pump.

In the pipe *g* between the generating chamber and the engine, I prefer to place a safety valve *a'*, and in pipes *t*, *k* and *y* check-valves *b'*, *c'* and *d'* are interposed to prevent a back flow due to a sudden high pressure in the generator.

The above-described arrangement of parts provides an operative system for automobile torpedoes which is simple, self-starting, self-regulating and well protected against accidents.

What I claim is:

1. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, a tank for an oxygen-carrier under pressure, a water supply, a fuel supply, an auxiliary source of pressure for the water and fuel supply, a conduit leading from the oxygen-carrier tank to the combustion chamber, a second conduit through which the pressure of the oxygen-carrier is applied to regulate the pressure of the fuel and water supply, valve mechanism controlling said conduits, connections through which the fuel and water may freely pass under the pressure of the oxygen-carrier into the generating chamber, and a connection from the combustion chamber to the driving engine of the torpedo, whereby the flow of water and fuel feed to the generator depends at all times upon and is regulated by the pressure of the oxygen-carrier, but the flow of the oxygen-carrier is independent of the water and fuel supply.

2. In an automobile torpedo, motive fluid generating apparatus comprising a tank for storing an oxygen-carrier under pressure, a combustion chamber having an outlet conduit leading to the driving engine, and a conduit extending from the storage tank to the combustion chamber, the said elements constituting a power system in which the stored oxygen-carrier may flow from the storage tank through the combustion chamber to the engine to operate it; in combination with means for supplying a combustible and water to the combustion chamber, and means for discontinuing the combustible supply upon failure of the water supply, without interrupting the flow of oxygen-carrier to and through the combustion chamber and thence to the engine.

3. In apparatus for generating motive fluid for automobile torpedoes, a tank for storing an oxygen-carrier under pressure, a water pump, and a source of fuel supply, a combustion chamber, a supply conduit from the oxygen-carrier tank to the combustion chamber, a driving engine, a conduit from the combustion chamber to the engine, a conduit from the water pump to the combustion chamber, a conduit from the fuel supply to the combustion chamber and a connection through which the pressure on the water supply is applied to the fuel supply; substantially as described.

4. In apparatus for generating motive fluid for automobile torpedoes, a tank for storing an oxygen-carrier under pressure, a water pump, and a source of fuel supply, a combustion chamber, a supply conduit from the oxygen-carrier tank to the combustion chamber, a driving engine, a conduit from the combustion chamber to the engine, a conduit from the water pump to the combustion chamber, a conduit from the fuel supply to the combustion chamber, a connection through which the pressure on the water supply is applied to the fuel supply, and a connection through which the pressure of the oxygen-carrier is applied to regulate the pressure of the fuel and water supply; substantially as described.

5. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, a water supply and a fuel supply, means for injecting the water and fuel into the generating chamber, a supply of oxygen-carrier under pressure, and a regulator controlled by the pressure of the oxygen-carrier and controlling the water and fuel supply.

6. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, a source of water supply under pressure for injecting water into the products of combustion, a fuel tank connected to the generating chamber, connections from the source of water supply to the fuel tank, a supply of oxygen-carrier under pressure, and a regulator controlled by the pressure of the oxygen-carrier for regulating the flow of water from the source of water supply to the generating chamber and fuel tank.

7. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, a source of water supply under pressure for injecting water into the products of combustion, a fuel tank connected to the generating chamber, connections from the source of water supply to the fuel tank, a supply of oxygen-carrier under pressure, and a regulator interposed in the connections from the source of water supply to the generating chamber and fuel tank for regulating the flow of water from the said source, said regulator comprising a casing, a flexible diaphragm dividing the casing into two chambers, with one of which chambers the inlet from the source of water supply and the outlet to the generating chamber and the fuel tank communicate, a valve connected to the diaphragm and controlling the inlet from the source of water supply, and connections for admitting the oxygen-carrier under pressure to the other chamber of the regulator casing.

8. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, inlet devices for the fuel and oxygen-carrier, a dome-shaped hood about said devices, and a water spray-head arranged to spray water on the outside of said hood.

9. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, inlet devices for the fuel and oxygen-carrier at the upper part of the generating chamber, a hood overhanging said inlet devices, and a water spray-head for directing jets of water on the outside of said hood.

10. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber having a dome-shaped upper end and in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, inlet devices for the fuel and oxygen-carrier at the upper part of the generating chamber, a hood overhanging said inlet devices and substantially conforming in shape to the dome-shaped upper end of the generating chamber and a centrally located water spray-head between the end of the chamber and the hood for directing jets of water on the outside of said hood.

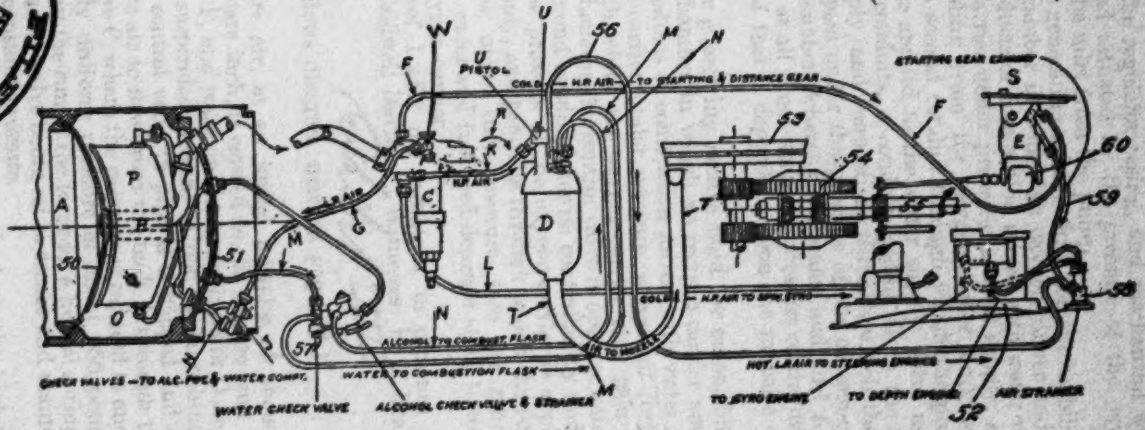
11. In apparatus for generating, motive fluid for automobile torpedoes, a tank for an oxygen-carrier under pressure, a fuel tank, a generating chamber, a regulator casing, a pump, and a fluid-operated motor, connections extending from the oxygen-carrier tank and from the fuel tank to the generating chamber, whereby the oxygen-carrier and fuel are admitted to the generating chamber to be burned therein, connections extending from the generating chamber to the fluid actuated motor and to the pump, whereby the products of combustion are led to the motor and pump to actuate the same, connections extending from the pump to the regulator casing and from the regulator casing to the fuel tank and to the generating chamber, a branch connection extending from the oxygen-

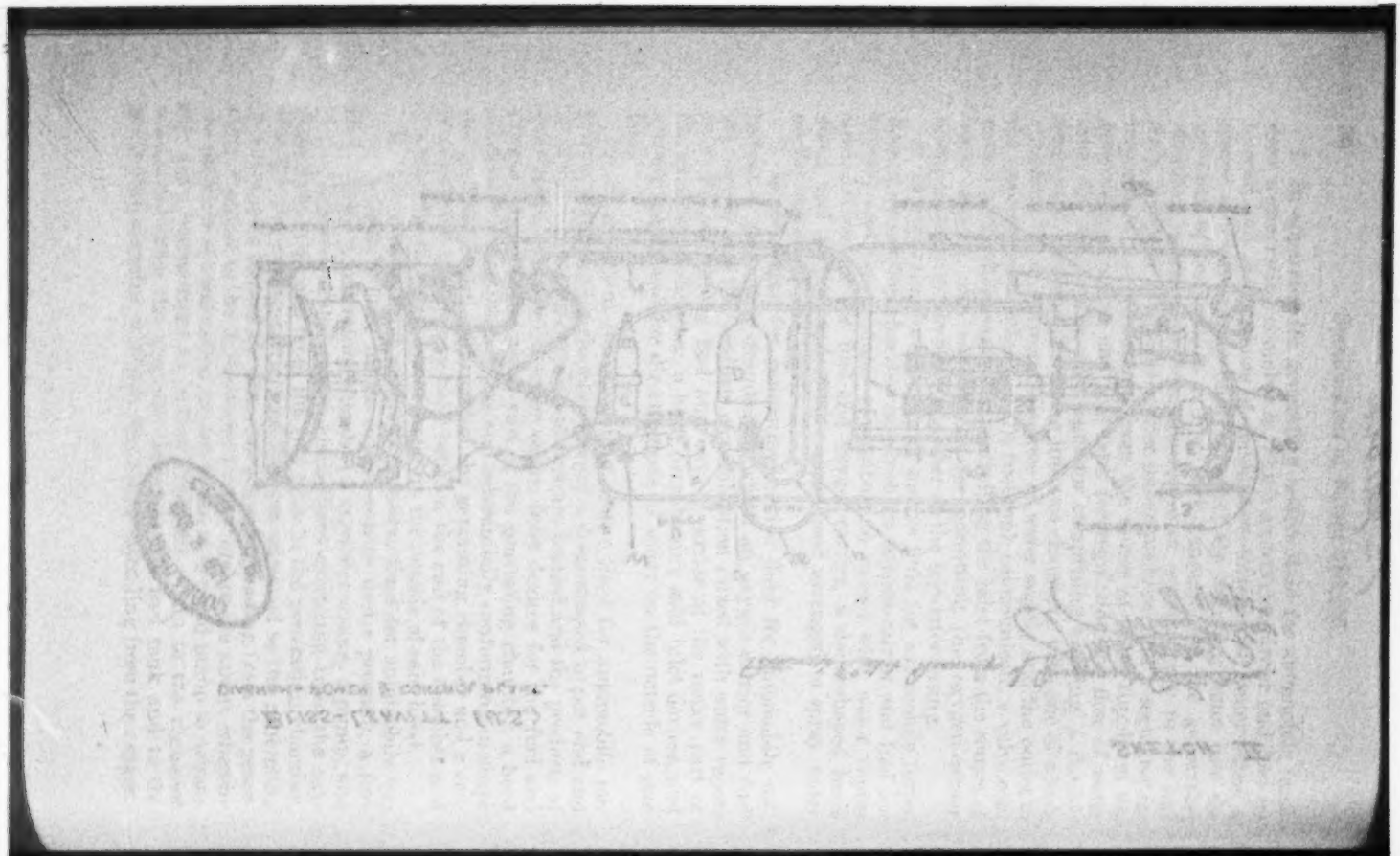
SKETCH II

BLISS-LEAVITT (U.S.)

DIAGRAM - POWER & CONTROL PLANT.

Witness's Exhibit. Drawing of Torpedo Installation.
J. Whitehead Swan
Notary Public
11/10/15.





carrier connections to the regulator casing, and mechanism within the regulator casing and actuated by the pressure of the oxygen-carrier for controlling the inlet from the pump.

12. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, a tank for an oxygen-carrier under pressure, a water supply, a fuel supply, a conduit leading from the oxygen-carrier tank to the combustion chamber, a second conduit through which the pressure of the oxygen-carrier is applied to the water supply, valve mechanism controlling said conduits, a conduit leading from the water supply to the fuel supply, and connections through which the fuel and water may freely pass under the pressure of the oxygen-carrier into the generating chamber, whereby the water and fuel feed to the generator, depends at all times upon the pressure of the oxygen-carrier, and the feed of fuel is dependent upon the pressure of the water supply.

13. In apparatus for generating motive fluid for automobile torpedoes, a generating chamber in which an oxygen-carrier and fuel are burned and the products of combustion mixed with water vapor, a tank for an oxygen-carrier under pressure, a conduit including a control valve through which the oxygen-carrier may pass to the generating chamber whenever the control valve is open, a water supply, a fuel supply, a second conduit likewise controlled by said valve and through which the pressure of the oxygen-carrier is applied to the fuel and water supply, and conduits through which the fuel and water may freely pass, under such pressure, into the generating chamber, whereby the water and fuel feed depends at all times upon the pressure of the oxygen-carrier.

In testimony whereof I affix my signature, in presence of two witnesses. Gregory Caldwell Davison. Witnesses: F. L. Brake, W. D. Fesler.

Exhibit III

(Here follows diagram marked page 42.)

43 High-pressure air, at an initial pressure of about 2,250 pounds per square inch, is carried in the storage tank A, fuel is carried in the tank P, and water in the space in tank O not taken up by the fuel tank P suspended therein. Upon the launching of the torpedo a starting or control valve in pipe B is tripped and opened, allowing high-pressure air to flow from the tank A through the pipe B to the reducing valve C, where the pressure is reduced to and maintained at a practically uniform pressure of about 350 pounds per square inch throughout the run of the torpedo, a helical spring in the lower part of the reducing valve being set to secure and maintain the desired reduced and constant pressure.

Pipes F and L conduct high-pressure air from the high-pressure side of the reducing valve to the starting and distance gearing and to the gyroscope, respectively; and another pipe, marked "H. P. Air," leads from the high-pressure side of the reducing valve to the

pistol U, which is an ignition device to start combustion in the generating chamber D.

The feed of fuel and water into the combustion and generating chamber D is effected by the pressure in the fuel and water tanks of low-pressure air conducted thereto from the low-pressure side of the reducing valve C by the pipe G and its branches H and J, the water and fuel being forced from said tanks to the chamber D through the pipes M and N, respectively, to permit which the pressure of the air in said chamber D is reduced some 40 or 50 pounds below the pressure of the air in the low-pressure side of the reducing valve and in the water and fuel tanks. This additional reduction in pressure is effected by a restriction in the passage R, conducting the air from the reducing valve to said chamber D. The difference between the pressure in the water and fuel tanks and the pressure in the generating chamber D is also slightly increased by a Pitot pressure in the pipe G conveying compressed air to the water and fuel tanks.

The fuel is sprayed into the upper part of the combustion and generating chamber so as to intermingle and produce a combustible mixture with the air admitted through perforations in the baffle plate in the upper part of the chamber, and the water is sprayed directly into said chamber, in the presence of the burning fuel, and there vaporized and mixed with the products of combustion.

44 **VIII. JUDGMENT OF THE COURT.**

[Filed June 26, 1922.]

At a Court of Claims held in the City of Washington on the 26th day of June, A. D. 1922, judgment was ordered to be entered as follows:

The Court, upon due consideration of the premises find in favor of the defendant, and do order, adjudge and decree that the plaintiff, as aforesaid, is not entitled to recover and shall not have and recover any sum in this action of and from the United States; and that the petition herein be and the same hereby is dismissed; And it is further ordered, adjudged and decreed, that the United States shall have and recover of and from the plaintiff, as aforesaid, the sum of Six Hundred and Five Dollars and thirty-four cents ($605.34), the cost of printing the record in this court, to be collected by the clerk as provided by law. By the Court.

IX. PROCEEDINGS AFTER THE ENTRY OF JUDGMENT.

On July 18, 1922, the plaintiff filed a motion to amend findings of fact filed June 26, 1922. Said motion was overruled by the Court October 16, 1922.

On September 30, 1922, the plaintiff filed a motion for leave to file a motion for amendment of findings. Said motion was overruled by the Court October 16, 1922.

45 **X. PLAINTIFF'S APPLICATION FOR AND ALLOWANCE OF AN APPEAL.**

[Filed Sept. 22, 1922.]

From the decision and judgment rendered in the above entitled cause on the 26th day of June, 1922, in favor of the defendants, the plaintiff, on the 22nd day of September, 1922, makes application for, and gives notice of, an appeal to the Supreme Court of the United States. The Electric Boat Company, by Pennie, Davis, Marvin & Edmonds. Dated: New York, N. Y. September 22, 1922.

Filed, Court of Claims, September 23, 1922.
Ordered: That the above appeal be allowed as prayed for. October 16, 1922. By the Court.

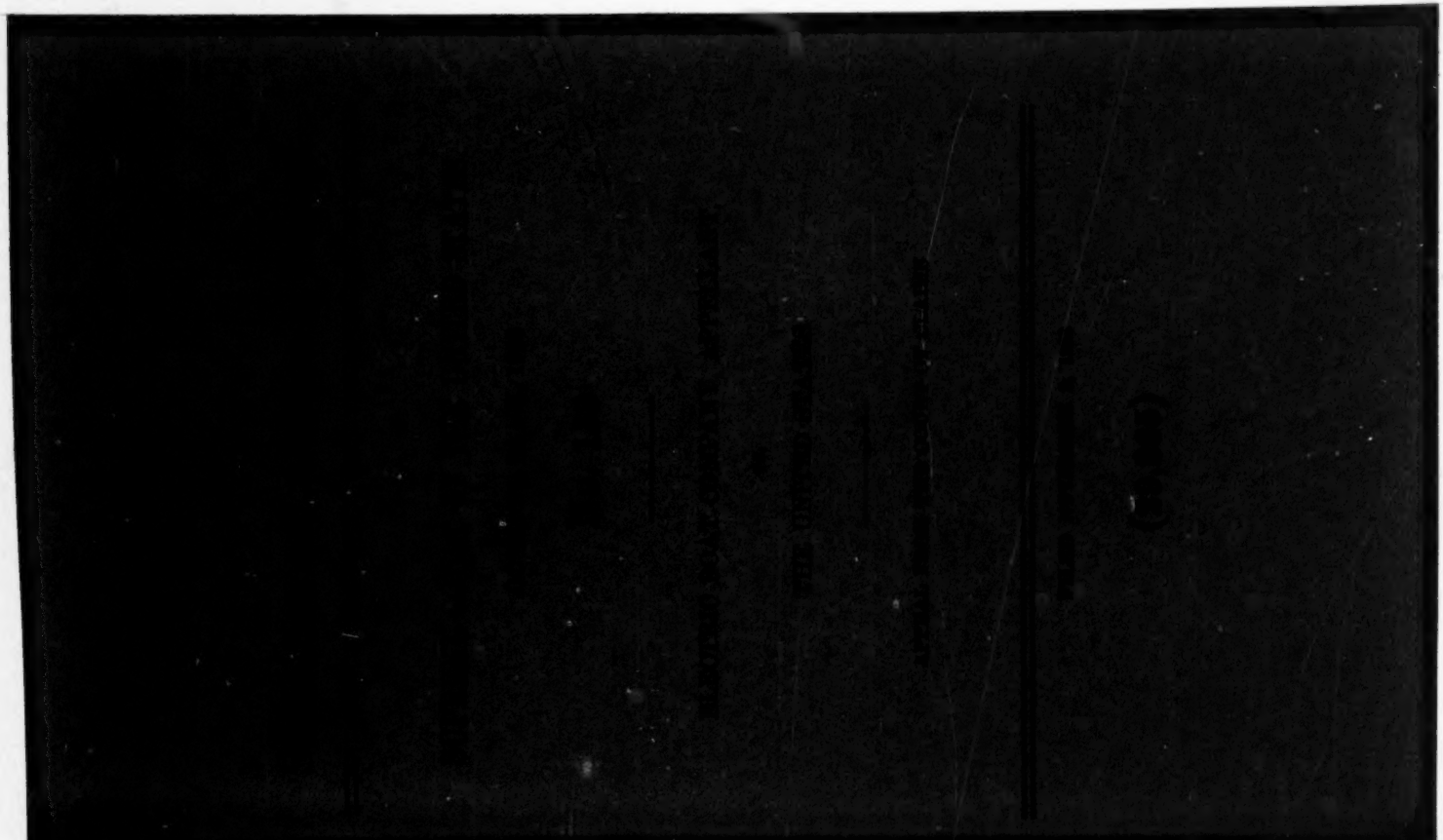
46 Court of Claims.

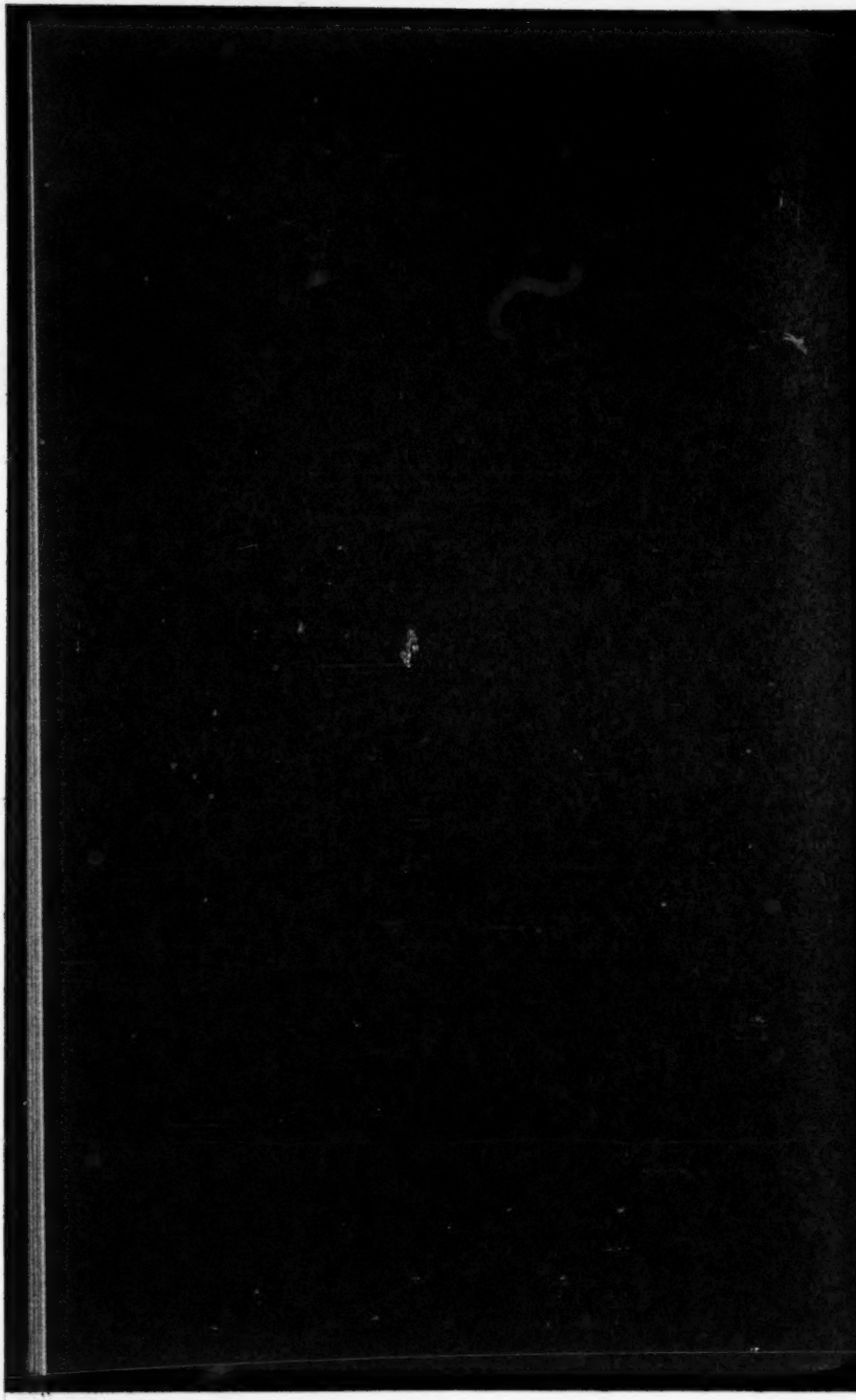
[Title omitted.]

I, F. C. Kleinschmidt, Assistant Clerk Court of Claims, certify that the foregoing are true transcripts of the pleadings in the above-entitled cause; of the argument and submission of case; of the findings of fact, conclusions of law and opinion per curiam; of the judgment of the Court; of the plaintiff's application for and the allowance of an appeal to the Supreme Court of the United States.

In testimony whereof I have hereunto set my hand and affixed the seal of said Court at Washington City this Third day of November, A. D., 1922. [Seal of Court of Claims.] F. C. Kleinschmidt, Assistant Clerk Court of Claims.

Endorsed on cover: File No. 29,265. Court of Claims. Term No. 715. Electric Boat Company, appellant, vs. The United States. Filed November 29th, 1922. File No. 29,265.





(29,265)

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1923

No. 159

ELECTRIC BOAT COMPANY, APPELLANT,

vs.

THE UNITED STATES

APPEAL FROM THE COURT OF CLAIMS

INDEX

JUDD & DETWEILER (INC.), PRINTERS, WASHINGTON, D. C., NOVEMBER 16, 1923

Sir W. G. Armstrong
No. 16997

[fol. 34] **SUPREME COURT OF THE UNITED STATES**

October Term 1923

No. 159

ELECTRIC BOAT COMPANY, Appellant,

vs.

THE UNITED STATES, Appellee

STIPULATION FOR ADDITION TO RECORD

It is hereby stipulated and agreed by and between counsel for the parties hereto that Exhibits B-1, B-2 and B-3 referred to in Finding XIII of the Findings of Fact, and Exhibits C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14 and C-15 referred to in Finding XIV of the Findings of Fact, be added to the record herein on appeal from the judgment of the United States Court of Claims.

Dean S. Edmonds, Counsel for Appellant. James M. Beck, Solicitor General, Counsel for Appellee. Dated, November 7, 1923.

[fol. 35] IN THE UNITED STATES SUPREME COURT

Washington, D. C.

[Title omitted]

STIPULATION TO OMIT PARTS OF RECORD

It is hereby stipulated and agreed by and between counsel for the parties hereto that Exhibits C-1, C-2, C-3, C-4, C-6 and C-9, referred to in Finding XIV of the Findings of Fact and which were inserted in the record by stipulation to that effect and dated November 7th, 1923, be omitted from the record herein on appeal from the judgment of the United States Court of Claims.

Dean S. Edmonds, Counsel for Appellant. James M. Beck, Counsel for Appellee. Dated November 13th, 1923.

[fol. 36] IN THE UNITED STATES SUPREME COURT

[Title omitted]

STIPULATION RE TRANSLATION

It is hereby stipulated and agreed by and between counsel for the parties hereto that the specification of British patent to Geszteesy

No. 18,241 of 1908 forming Exhibit C-12 shall be accepted as a translation of the specification of French patent to Gesztesy No. 393,324, forming Exhibit C-13.

It is further stipulated that the document annexed hereto is an accurate translation of the article published in Revista Maritima Braziliera for January, 1908, forming Exhibit C-14.

Dean S. Edmonds, Counsel for Appellant. James M. Beck, Solicitor General Counsel for Appellee. Dated November 7, 1923.

[fol. 37] GESZTEZY AIR WARMER FOR TORPEDOES

Of the apparatus intended for warming the air during the course of the torpedo and at present undergoing experiment at the Whitehead firm, it appears to us that the warmer invented by First lieutenant Gesztezy of the Austrian Navy will be the one preferred if the lauching tests have the same result as the preliminary experiments.

Up to the present the chief advantage of this apparatus over the Armstrong device is that it enables the engine of the torpedo to preserve all its bronze parts, which is not the case with the English warmer, in which, owing to its temperature, it becomes necessary to use steel in the pistons and distributing valves, so that the preservation of the motor is therefore difficult.

It is impossible for us to say wherein the operation of the Armstrong warmer consists, for the two torpedoes in which this apparatus is making its experiments are not dismounted in the sight of strangers.

However, as regards the Gesztezy warmer, the preliminary experiments with which were not secret and the diagram of which we were able to obtain, we shall do everything possible in order to give a general idea of its operation.

In the torpedo in which this warmer is mounted, it occupies the [fol. 38] compartment of the immersion regulators, the torpedo using the new immersion regulator placed in the engine compartment.

The purpose of the Gesztezy warmer is to quickly convert into steam the water contained in a reservoir, this steam proceeding together with the air to perform in the engine the rôle of warmed air.

The complete apparatus is composed as follows:

Warming apparatus proper E.
Retarding apparatus I.
Fuel (benzine) chamber F.
Water Chamber G.
Pistol H.

The warming apparatus is composed of the external bell T, having on the inside the cylindrical vessel t which limits the space for the combustion, the circular space d remaining between it and the external bell.

The internal vessel t diminishes in diameter at the lower part f, the large circular space c forming; at the bottom of t the tube a starts, terminating at the top by a cylindrical body g, where the elongated apertures h are situated.

By means of this body, the part of least diameter of t is divided into two parts, which are in communication solely by means of a small circular space, the upper part still remaining in communication with the space e by means of the holes i.

[fol. 39] In the bell T is the circular channel l, which is in communication with the water-conducting tube m, and by means of the holes n, with the space t.

To the warming apparatus is fixed the pistol H, where a small cartridge is detonated by percussion through the pressure of the air, brought to the pistol through the tube r.

The fuel and water chambers F and G are simple vessels in which are situated two tubes, one for the exit of the liquid and the other for the entrance of the air.

The pressure regulator D is the same one used in torpedoes.

The operation of the apparatus is as follows:

The air coming from the reservoir, upon finding the preservation and admission valves open, continues through the tube k to the pressure regulator, whence after being reduced to the proper pressure, it continues on to the retarding apparatus I; from here the tubes of small diameter p. o. r. conduct air to the water and combustion chambers and to the pistol.

When the work is terminated in the retarding apparatus the air goes on to the warmer through the tube k′, which terminates at the circular space e; here the air is divided into two parts, a small part [fol. 40] penetrating into the holes I, drawing away the benzine which quickly issues through the holes h, to the middle of the vessel t, where the mixture is ignited; the other part of the air continues through the space d to the upper part of the apparatus, carrying along and dispersing the water, which quickly issues through the holes n.

In the upper part of the apparatus there then takes place a union of the products of combustion with the air impregnated with water, the latter being instantaneously converted into steam and continuing on with the air to the engine, through the tube M.

The retarding apparatus, the internal view of which is not shown in the diagram, is the principal part of the apparatus, constituting, we heard a separate patent.

The purpose of this apparatus is only to permit a minimum pressure during the first moments of the course of the torpedo, increasing it gradually until the normal is reached.

The apparatus of Lieutenant Wesztezy possesses the following further advantages.

1. The first ignition of the mixture occurs with very small pressure, so that the sudden increase of pressure, due to the ignition can not have any disadvantageous consequence for the motor.

[fol. 41] 2. In launchings, the apparatus only enables the engine to work with full force after the torpedo has entered the water, so that the retarder now used becomes unnecessary.

3. By means of a suitable arrangement of the air-conducting tubes, it is possible to regulate exactly the moment of introduction of the benzine and of the water, as well as the instant of ignition.

The apparatus, as it is at present, weighs, with the chambers empty, 25 kg., the water chamber having a capacity of 8.5 1. and the benzine chamber 1.1 1.

Fiume, November, 1907.

L. Neves, Second Lieutenant.

(Here follow side folio pages 42-47, inclusive)

[fols. 48-59] EXHIBITS C-1 AND C-2—Omitted in printing

(Here follows Exhibit C-3, marked side folio pages 60-66)

[fols. 67-71] EXHIBIT C-4—Omitted in printing

(Here follow side folio pages 72-74)

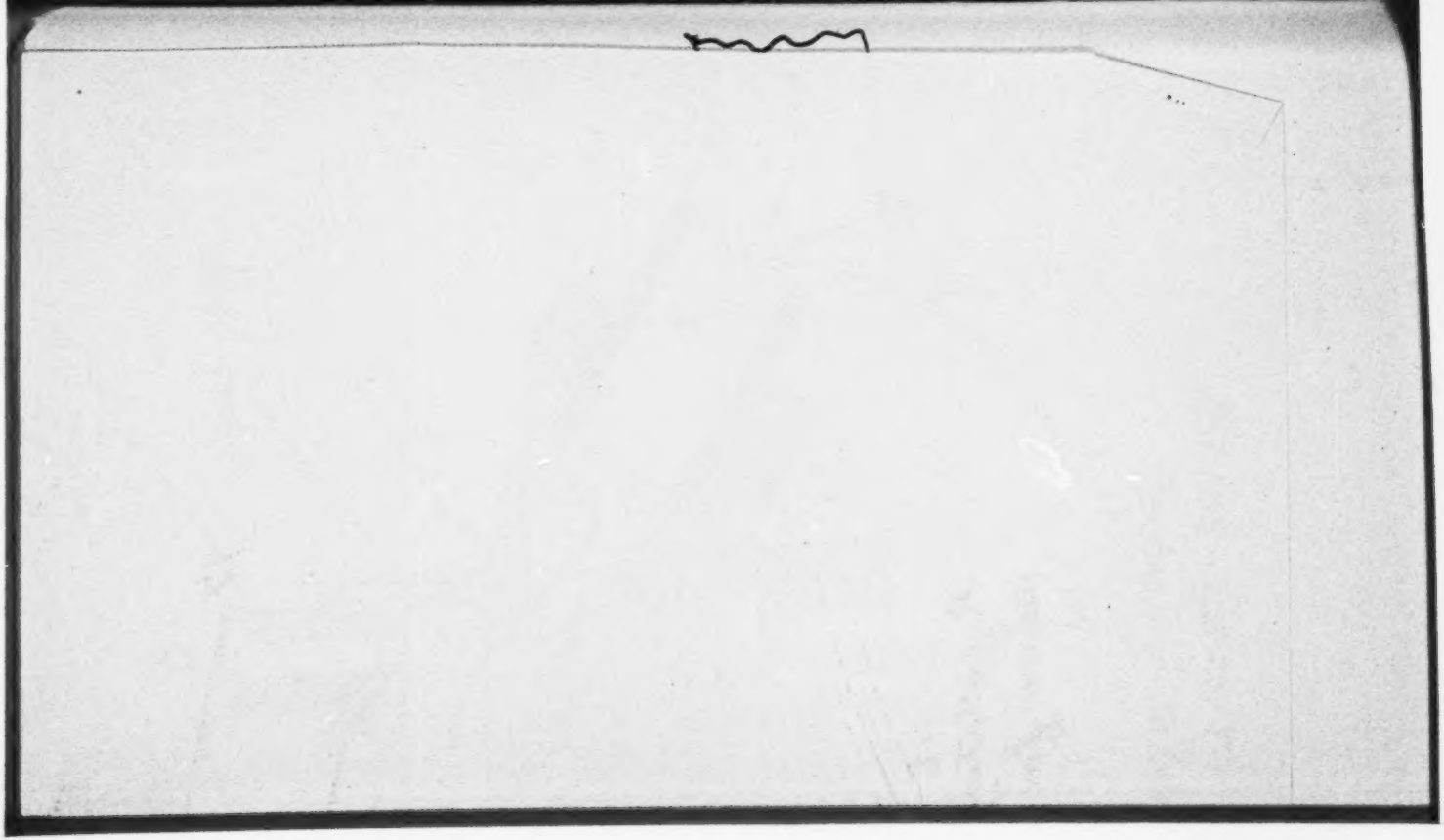
[Matter apparently omitted here.—Printer.]

[fol. 75] chambers and nozzles must be provided for the turbines, or the combustion chambers already provided are adapted to both methods of operation. This involves valves and connections which can rapidly change the operation of the turbines from the simple air oil cycle to that in which air or oxygen and oil are used, but in which water is added to make up for the air which would have been used to form the necessary balance of working fluid to enable the heat to be satisfactorily utilised.

The object of my methods for driving submarine or submersible boats is to enable the boat to be so fitted that the same driving mechanism which propels it on the surface is able to be used with the highest possible economy below water, in relation to the amount of propelling material which is stored and carried in the boat for under surface working.

The methods which I have described are such as to give great economy and therefore to give the largest number of horse-power-hours for the weight of stored material which is carried. A further great advantage in relation to other methods is that maximum horse-power may be obtained for moderate periods of time in running under water; or on the other hand the storage by this method and special adaptation to the turbine may be so used as to give considerably more than the surface working maximum for short periods of increased speed under water.

I may also use the same methods of operation for the propulsion of motor cars or other vehicles where it is desired to obtain great



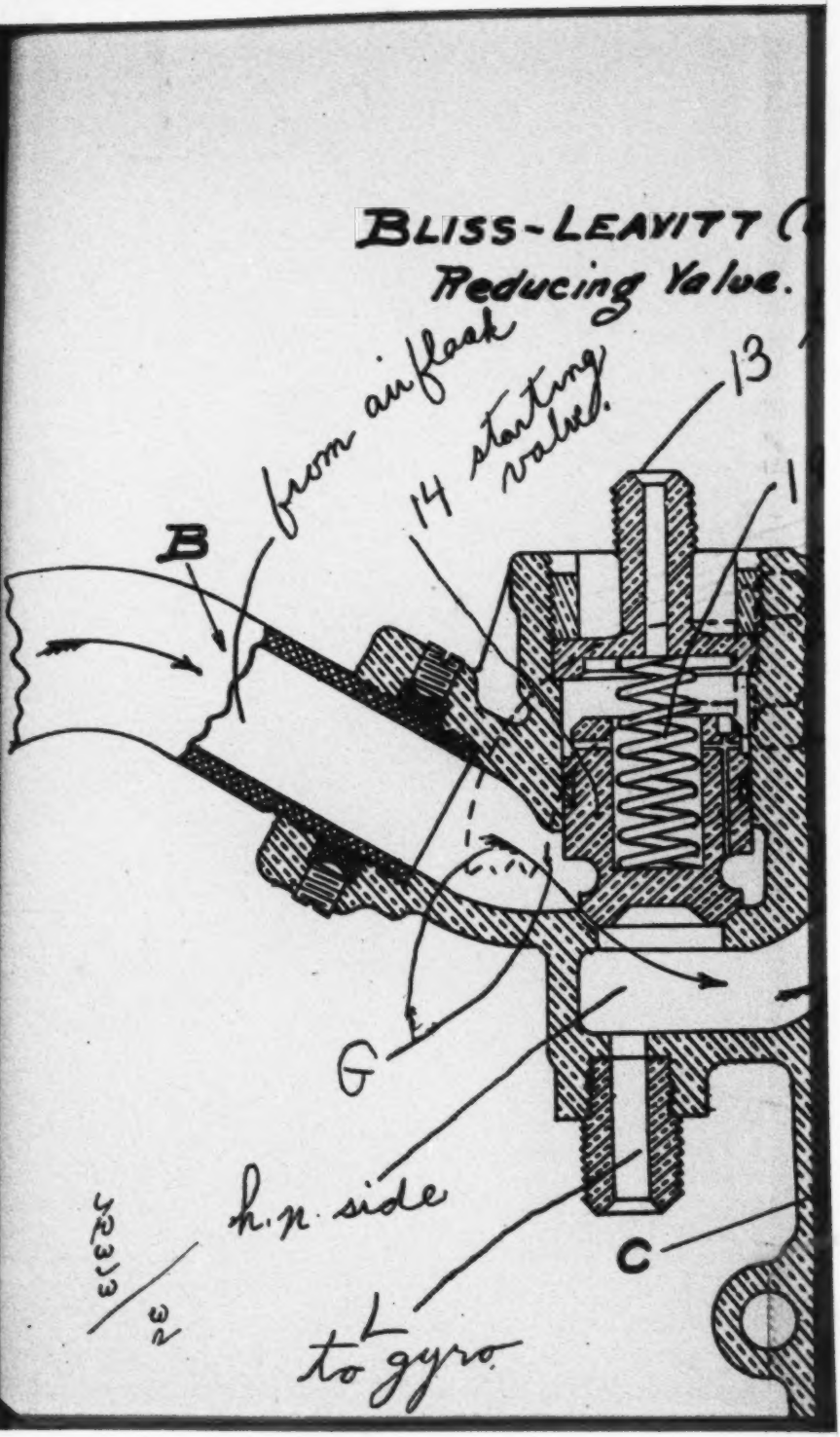
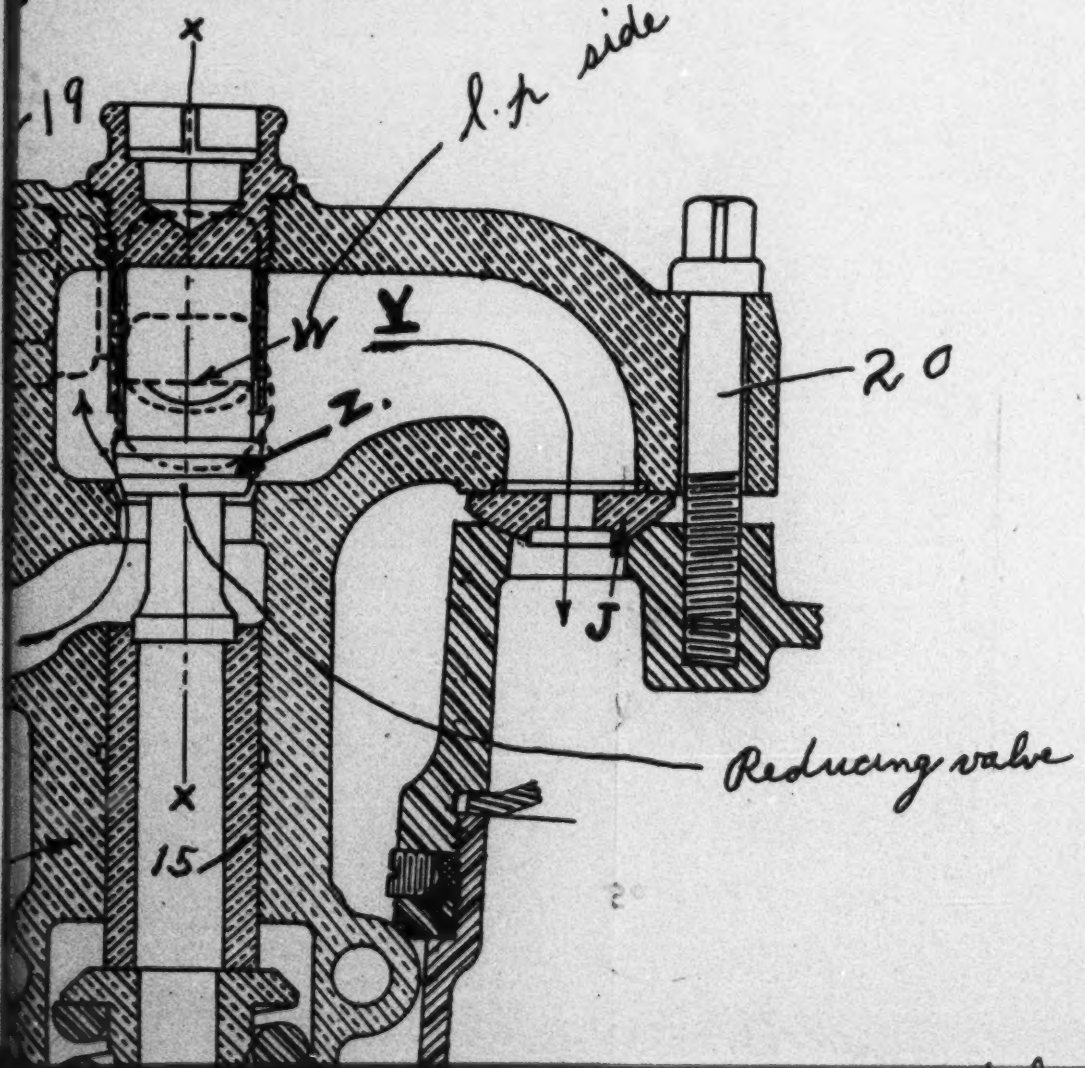
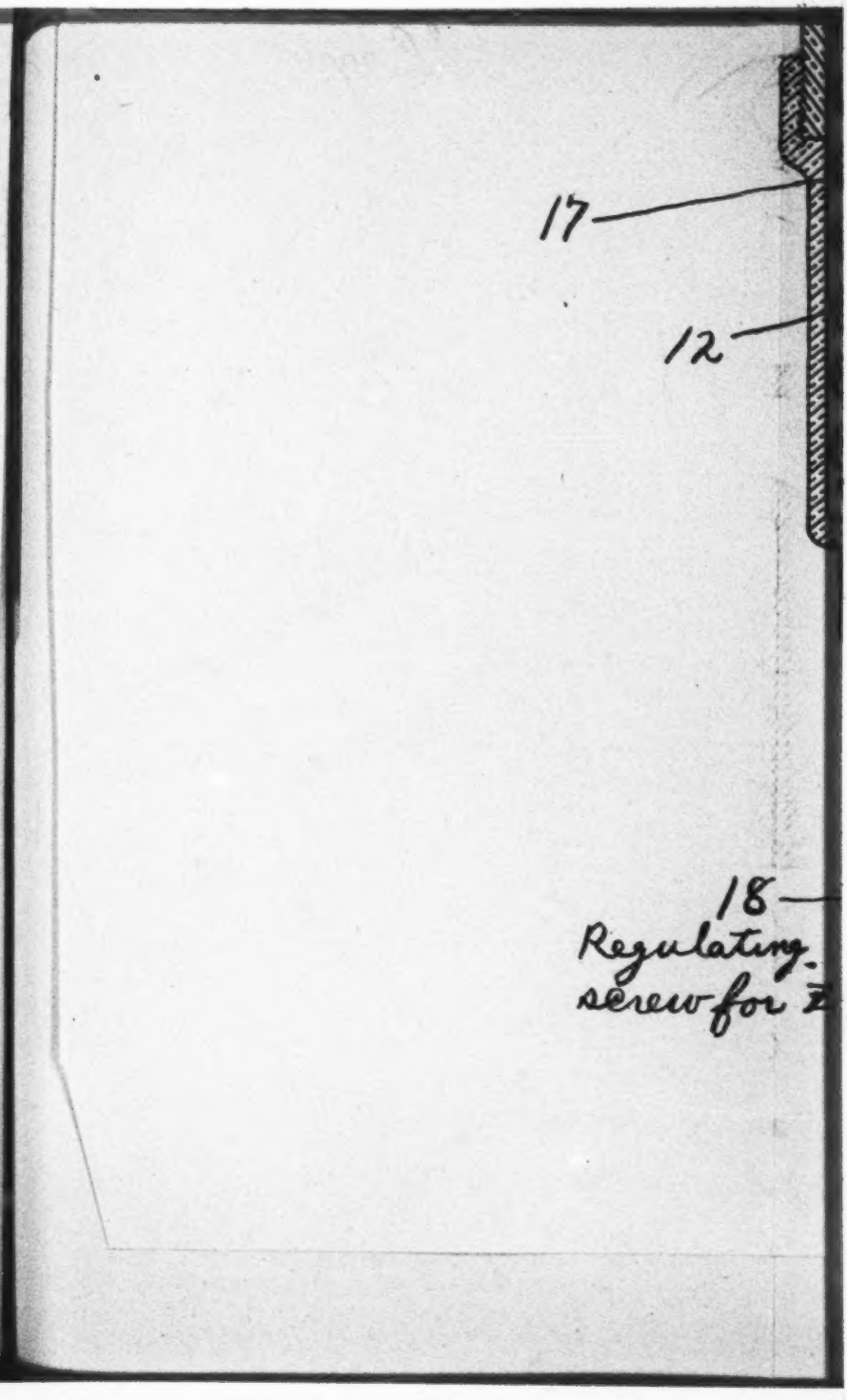

BLISS-LEAVITT
Reducing Valve.
from airflask
14 starting valve.
13
B
G
h. p. side
C
to gyro

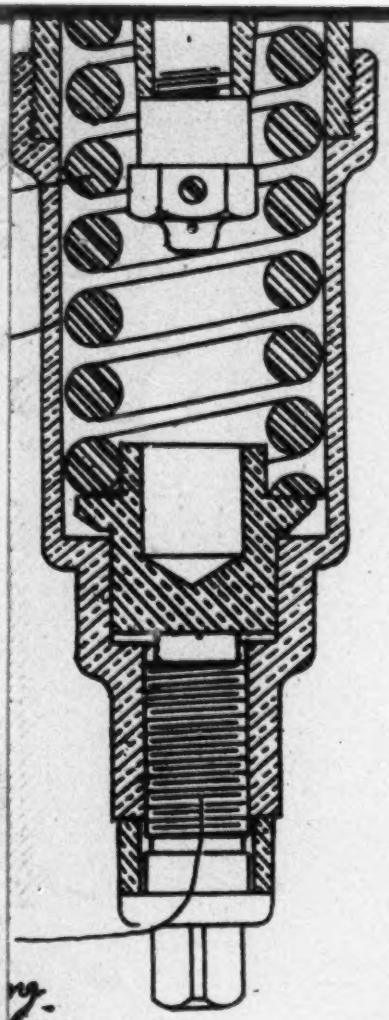
Exhibit B-1 to Court's findings

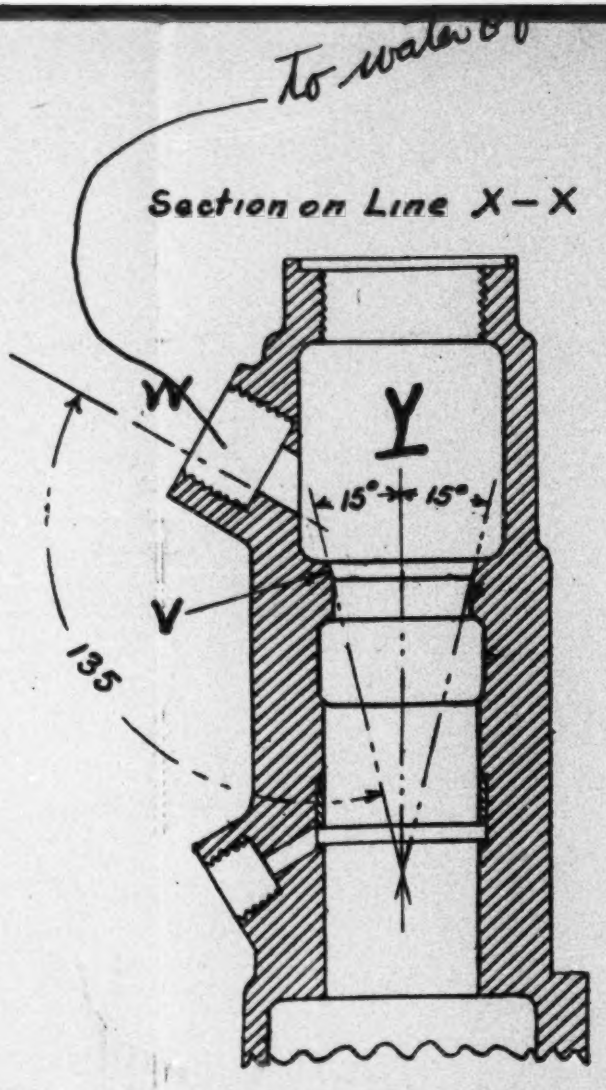
(U.S.) to starting & distance gear

SKETCH IV.




17
12
18
Regulating
screw for



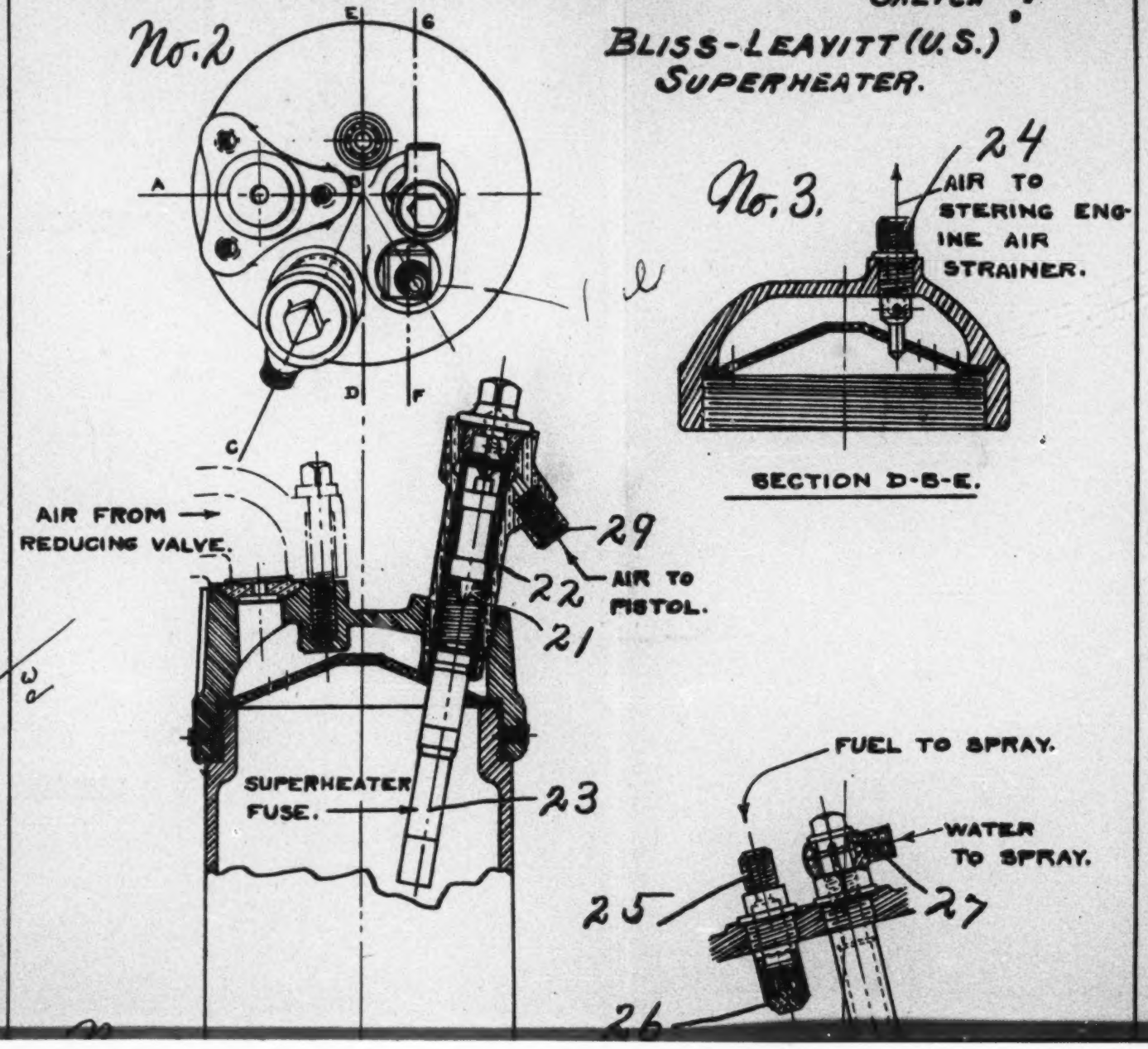


Pages 42–43

B-2 to Counts findings Pages 44-45

SKETCH V

BLISS-LEAVITT (U.S.) SUPERHEATER.

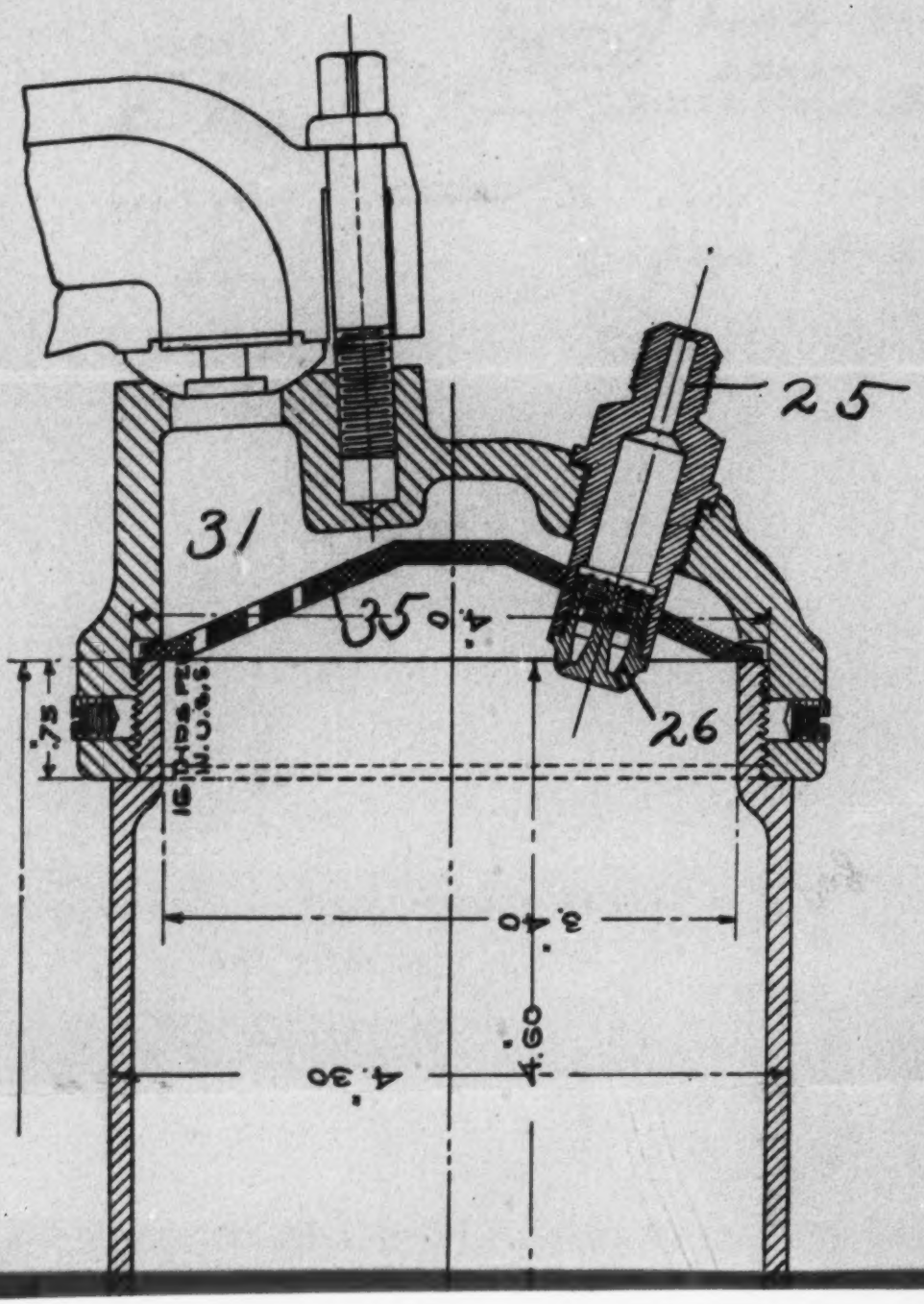


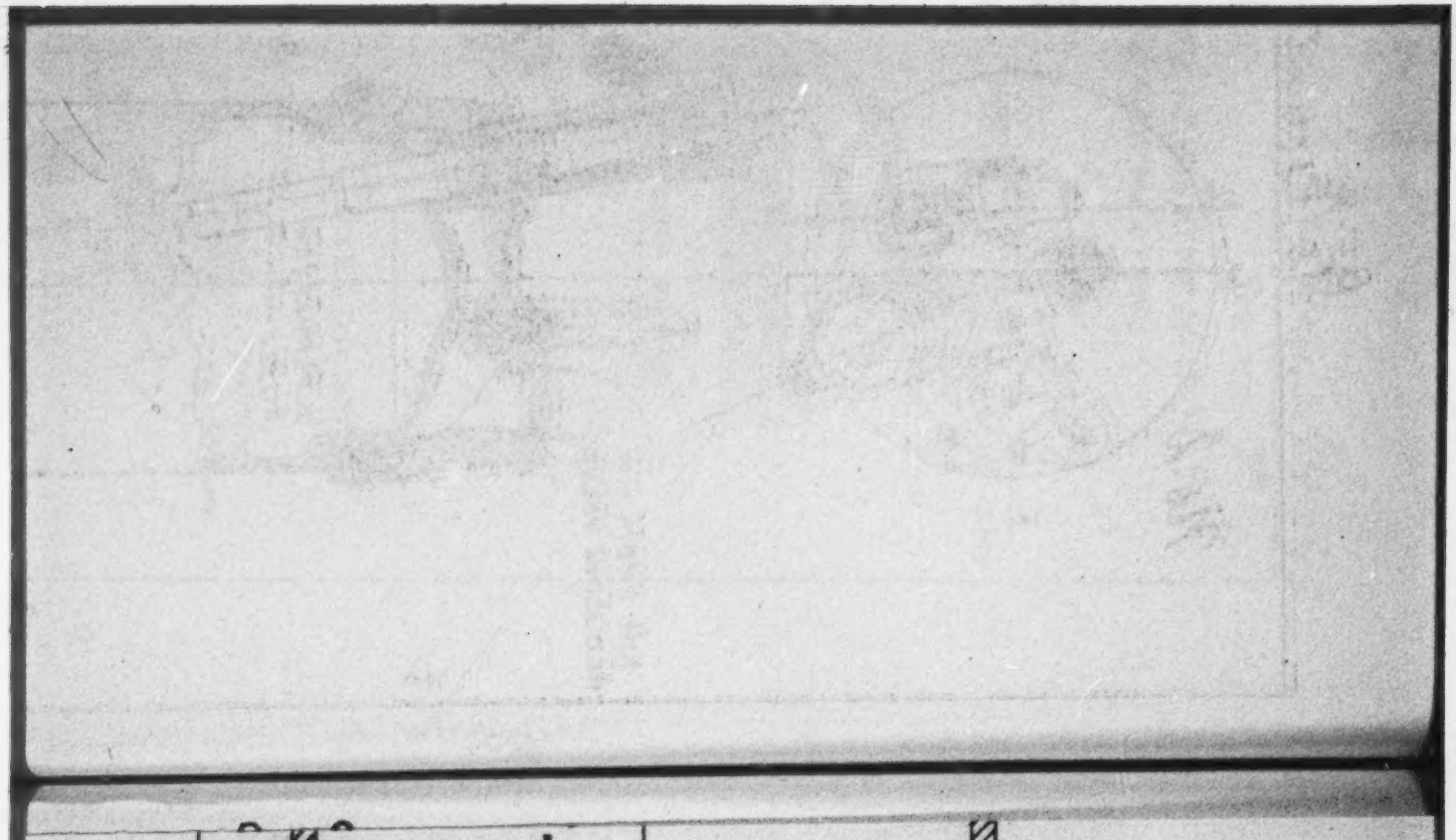
B-3
to Courts findings

SKETCH VI

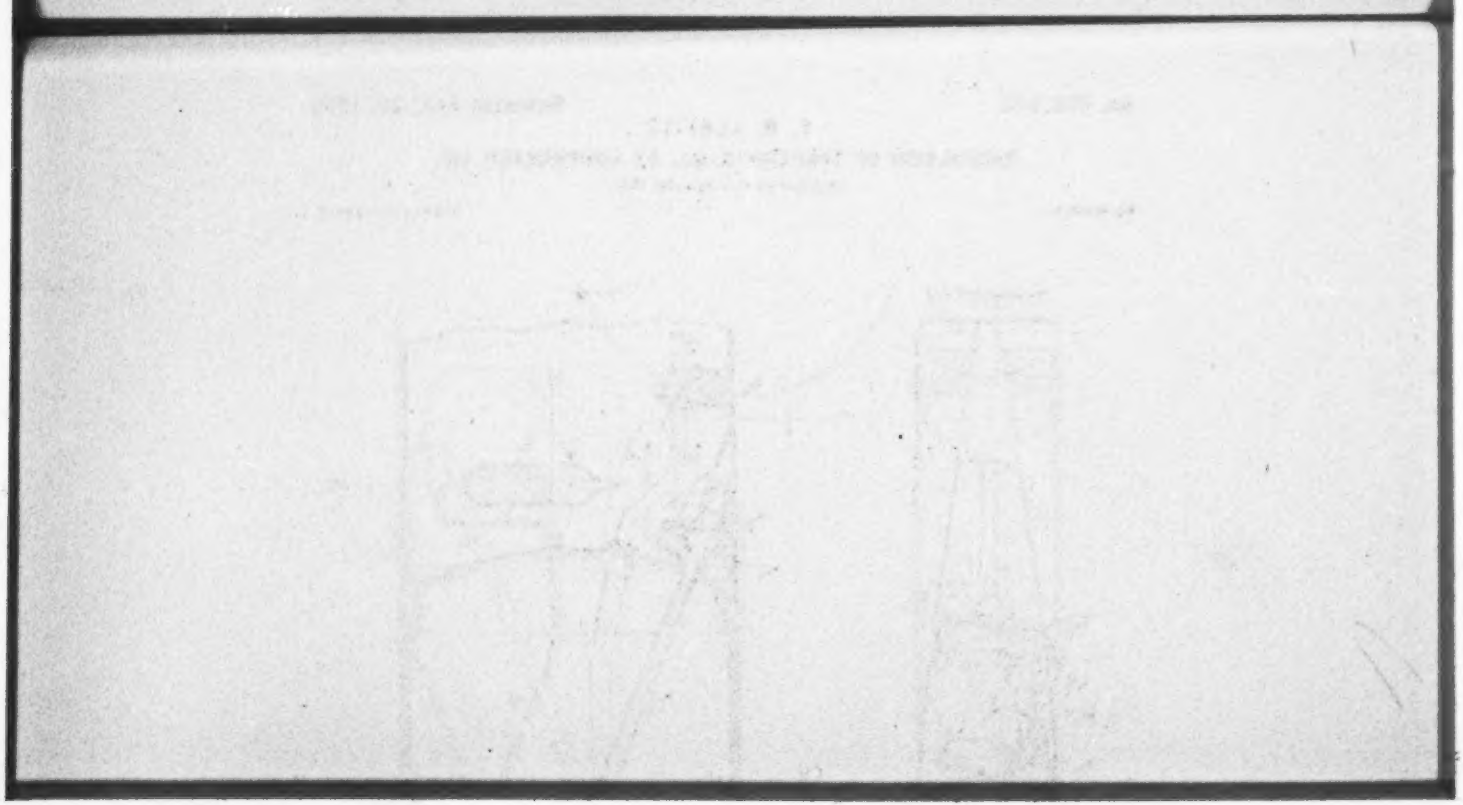
CROSS SECTION OF
BLISS-LEAVITT (U.S.) SUPERHEATER.

Pages 46-47





4:1 Scale
Top Part
34
12343
20 THDS PER IN.
U.S.S.
1.25"
1.0"
1.375"
.25"
2.0 R
.15"
7.52"



No. 693,872. Patented Feb. 25, 1902.

F. M. LEAVITT.

PROPULSION OF TORPEDOES, &c., BY COMPRESSED AIR.

(Application filed Apr. 12, 1900.)

(No Model.) 2 Sheets—Sheet 2.

FIG 4.

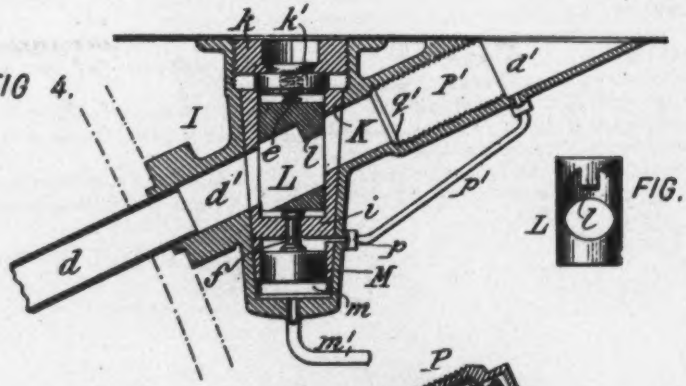


FIG. 7.

FIG. 5.

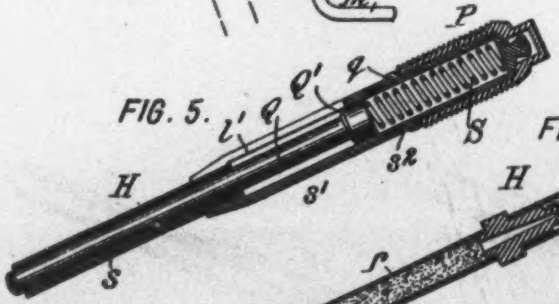


FIG. 6.

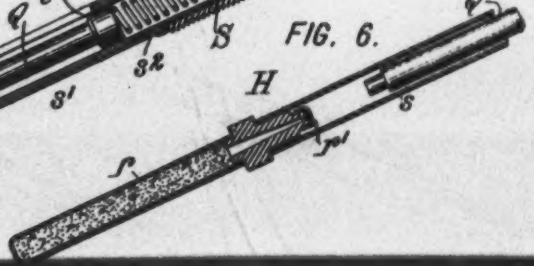


FIG. 8.

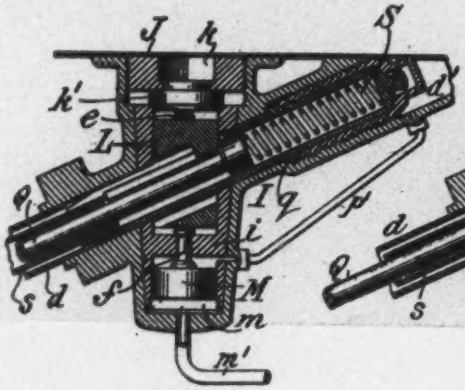
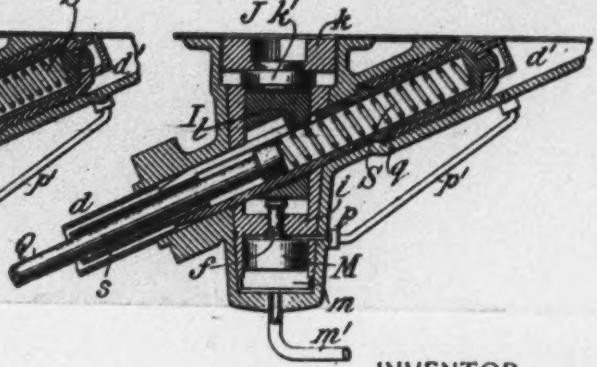


FIG. 9.



WITNESSES:

Jos. Whitz

Thomas F. Wallace

INVENTOR:

Frank M. Learitt.

By Attorneys,

Arthur G. Brieser & Co.

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UNITED STATES PATENT OFFICE.

FRANK M. LEAVITT, OF BROOKLYN, NEW YORK, ASSIGNOR TO E. W. BLISS COMPANY, OF BROOKLYN, NEW YORK, A CORPORATION OF WEST VIRGINIA.

PROPULSION OF TORPEDOES, &c., BY COMPRESSED AIR.

SPECIFICATION forming part of Letters Patent No. 693,872, dated February 25, 1902.

Application filed April 12, 1900. Serial No. 12,545. (No model.)

To all whom it may concern:

Be it known that I, FRANK M. LEAVITT, a citizen of the United States, residing in the borough of Brooklyn, county of Kings, city and State of New York, have invented certain new and useful Improvements in the Propulsion of Torpedoes, &c., by Compressed Air, of which the following is a specification.

This invention provides improved means for storing and generating power from compressed air especially applicable for use in automobile torpedoes, although in part available for the propulsion of other moving bodies or vehicles by means of the power stored in a reservoir of air under very heavy pressure.

My invention is applicable where air is compressed to a high pressure in a reservoir or flask, being left stored therein until ready for use, whereupon the compressed air is passed through a pipe to the engine or motor which it drives. This is the system heretofore used for the propulsion of the Whitehead torpedo. According to my invention I apply heat to the compressed air in the reservoir by effecting a combustion therein of a suitable combustible material, such as a liquid hydrocarbon. Hence I provide a suitable charge of such combustible material, either in the compressed-air reservoir itself or preferably in a chamber communicating therewith, and when ready to utilize the power of the compressed air I ignite the combustible material and cause it to burn within the reservoir, so that its combustion serves to heat the air, and so increase its mechanical efficiency or capacity to do work. I effect the combustion of such material in a gradual and progressive manner, preferably by feeding it into the reservoir at a rate proportional to the fall of the pressure of air therein.

My invention also relates to means for igniting the combustible charge at or shortly after the turning on of compressed air to start the engine.

My invention also relates to means whereby the igniter is set in operation by the launching of the torpedo.

Having thus indicated the nature of my invention, I will proceed to explain the preferred mode of applying the same with reference to the accompanying drawings, which show it as applied in connection with an automobile torpedo, and wherein—

Figure 1 is a longitudinal mid-section of the torpedo, showing its propelling and starting mechanism. Fig. 2 is a fragmentary vertical section of the middle portion of Fig. 1, showing the parts more in detail. Fig. 3 is a transverse section on the line 3 3 in Fig. 2. Figs. 4, 5, and 6 are enlarged detail views of the igniting mechanism in vertical longitudinal mid-section. Fig. 7 is a rear elevation of the cocking-plunger removed. Figs. 8 and 9 are vertical longitudinal mid-sections of the igniting mechanism, showing it before and after action.

In the drawings let A designate a compressed-air reservoir or flask; B, an engine or motor to be driven by the compressed air; C, a chamber containing the combustible material, and *a* a pipe conveying compressed air from the reservoir to the motor. Preferably I place within the reservoir A a receptacle or vessel D, having an open top, but partly covered over by a hood E. A pipe *b* connects the bottom of the chamber C with the bottom of the receptacle D. The chamber C may be placed outside of the reservoir A, as shown, or, if preferred, it may be placed within the reservoir. In the former case the pipe *b* passes through the wall of the reservoir at some suitable point. The chamber C has a removable cap or filling-plug *c*, which may conveniently open through the shell of the torpedo, as shown in Fig. 3, and from which a tube *c'* leads down into the chamber C to a suitable depth, so that in filling the chamber with the combustible liquid an air-space will be left above the liquid, as at c^3. The pipe *a* is extended within the reservoir by a pipe *a'*, connecting it with the hood E, so that the compressed air passing from the reservoir to the engine is compelled to circulate first into the chamber D, as indicated by the arrows in Fig. 2. Communicating with this pipe I have shown a valve F, which is the ordinary charging-valve for automobile torpedoes, through which compressed air is forced into the reservoir. The pipe *a* leads to any suitable valve

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for controlling the admission of compressed air to the engine in order to start the engine, and for this purpose I have shown at G the ordinary starting and pressure-reducing valve used in the Whitehead torpedo, with its starting arm or hook *y*, by which the valve is opened, in the act of launching the torpedo in the well-known manner; but any other valve or controlling means may be provided, my invention having no relation to this feature.

Before describing the igniting mechanism I will describe the operation of the system.

Before admitting air into the reservoir A and while its contents are at atmospheric pressure the plug *c* is removed, and the required quantity of alcohol or other suitable liquid hydrocarbon is poured into the chamber C, so as to fill it to the level *x* established by the lower end of the tube *c'*, thereby leaving the air-space c^3 above the liquid. The pipe *b* extends so high that no liquid will run over into the receptacle D while filling the chamber C. The plug *c* is then tightly closed, and the reservoir being otherwise hermetically sealed air is pumped in through the valve F and pipes *a a'* until the desired pressure is obtained—for example, fifteen hundred pounds per square inch—whereupon the admission-valve is closed or plugged, and the air thus introduced is left stored in the reservoir until power is to be applied. During this compression of the air as fast as its pressure exceeds that in the air-space c^3 it displaces the column of liquid in the tube *b* and bubbles up through the liquid in chamber C, so that the air in the space c^3 is compressed to the same pressure as that in the reservoir. When it is desired to apply the power thus stored, the starting-valve G is opened to admit the air to the motor B. As soon as the air begins to escape from the reservoir its pressure diminishes and the air in the space c^3 expands and gradually forces the liquid to flow from the chamber C into the receptacle D. In the system shown all the compressed air is assumed to be in a gaseous condition, and the reservoir comprises but one compartment, which serves for carrying both the store of compressed air and the receptacle D, instead of comprising two communicating compartments for the air and the receptacle D, respectively, as would be the case if the compression of the air had been carried to the point of liquidity. At a suitable time the combustible liquid is ignited in the receptacle D, (by any suitable igniting means, preferably that to be hereinafter described,) so that the liquid will burn in the receptacle D, its combustion being supported by the compressed air, so that it burns rapidly, and its heat being given up to the compressed air, so that the latter is increased in efficiency. The flames and hot gases resulting from this combustion mingle with the stream of air which is flowing into the receptacle D and out through the hood E and pipe *a'*, the space around the hood being made amply wide to permit a flow of air so slow as to avoid blowing out the flame. By the gradual expansion of the air in the space c^3 as the pressure in the reservoir diminishes the combustible liquid is gradually and progressively fed into the receptacle D. Hence by suitably proportioning the volume of the air-space c^3 to the quantity of alcohol or other liquid the flow of the latter into the reservoir may be graduated to any proportionate rate desired. I prefer to adopt such proportion that the flow of alcohol shall be continuous during nearly the entire period of generation of power, so that the last of it will not be consumed until shortly before the pressure falls to a minimum at which it is no longer available for power purposes.

The energy stored in a given weight of air, or, in other words, its capacity to perform work, is in direct proportion to its absolute temperature. It therefore results from my invention that the efficiency of the air is so increased by the heat of combustion within the reservoir that a greater amount of power can be obtained with a given weight of air for the same period of time than the same weight of air can be made to produce when not heated. In practice I have found it practicable to add sufficient heat to increase the work done by the air about fifty per cent. My invention also avoids the disadvantage of the cooling of the engine and passages due to the expansion of the compressed air.

I will now describe the igniting means.

I provide a tube *d*, leading through the reservoir from its exterior to the receptacle D, through which tube I may introduce an igniter H, which is shown partly in dotted lines in Fig. 2 and which in its preferred form is shown in detail removed in Figs. 5 and 6. At the outer end of the tube *d* I provide a lock or cocking mechanism which as a whole is designated J. This mechanism is contained within a shell I, (shown best in Fig. 4,) which is adapted to withstand the heavy pressure and provides a means for closing the outer end of the tube *d* against this pressure. Within this shell is fitted a plug or casing K, which is preferably coned exteriorly and is ground to fit a coned socket in the shell I, so as to make an air-tight joint. In the upper part of this plug K is a cylindrical chamber in which moves a plunger L. (Shown separately in Fig. 7.) In the lower part of the plug is formed a cylindrical chamber in which moves a piston M, these chambers being separated by a partition *i*. The plug K is held down within the shell I by a screw-plug *k*, which screws into a threaded socket in the shell I and carries a disk or cap *k'*, which makes a tight joint with the top of the plug K, so that air cannot escape from the interior of this plug. The plunger L is pressed down by a spring *e*, seated within the cap *k'*. Through the partition *i* passes a rod or valve-stem *f*. This stem has at its upper end a coned valve or head which when it is down seats against a

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coned seat in the upper part of the partition *i*, and at its lower end it carries a coned valve which when it is moved up seats in a coned seat formed at the lower side of this partition, thereby preventing leakage of air around the stem when it is in either position. The chamber *m* beneath the piston M communicates by a pipe *m'* with the compressed-air conduit at any point between the valve G and the engine B—as, for example, with the valve-chest of the engine—as shown in Fig. 1, so that when air is turned onto the engine it will flow back through the pipe *m'* and force up the piston M. The chamber above this piston is vented to the outer air by a passage *p*, which is preferably led by a pipe *p'* to an outlet beyond the igniting mechanism, as shown. The tube *d* is continued through the shell I by an oblique passage *d'* therein and in the plug K, as shown in Fig. 4, this passage leading to the exterior. Through this bore or passage the igniter H is inserted. This igniter is tubular and has a flange *q*, which is ground to a tight fit with a shoulder *q'* in the shell I, and when the igniter is in place it is forced tightly against this shoulder by means of a cap or screw-plug P, which screws into a threaded socket P' in the shell I, so that air cannot escape around the igniter. The igniter is preferably a percussion fuse or primer of the construction shown in Figs. 5 and 6. It carries at its lower end a cartridge *r*, containing a slow-burning powder or other suitable combustible, which when the igniter is in place projects within the receptacle D, as shown in Fig. 2. An ordinary percussion-cap *r'* serves for igniting this cartridge. The cartridge is carried at the end of a tube *s*, which passes through the tube *d* and at its upper end is joined to a tubular shell *s'*, Fig. 5, of larger bore, which preferably is made in two sections, its upper part *s²* forming a cap. A rod Q, forming a firing pin or hammer, is arranged to slide in the tube *s* and has at its upper end an enlarged head Q', which slides in the enlarged bore of the sleeve *s'*. A stiff spring S presses against this head, being housed within the cap *s²*. The hammer is held elevated or retracted by the plunger L, which acts as a trigger and which has a tooth or scar *l*, which projects through a slot *l'* in the upper side of the sleeve *s'*, Fig. 5, and engages the head Q' in the manner shown in Fig. 8, where the hammer is cocked, its spring S being compressed. In introducing the igniter it is passed down through the passage *d'* until the scar *l* of the plunger, which is pressed down by its spring *e* to the position shown in Fig. 4, catches the head Q', whereupon the cap P is screwed in and forces down the igniter until its flange *q* seats against the shoulder *q'*. In this operation the hammer, being held stationary by the scar, the spring S is compressed, as shown in Fig. 8.

In operation the launching of the torpedo throws the hook *g* into position to open the starting-valve G, which admits air-pressure to the engine and also admits compressed air through the tube *m'* to force up the piston M, which, acting through its stem *f*, pushes up the plunger L, and thereby withdraws the scar *l* and releases the hammer, which is forcibly thrown down by its spring S to the position shown in Fig. 9, so that its lower end strikes the cap *r'* and ignites the cartridge, which in turn ignites the combustible material in the receptacle D. The cartridge *r* is slow-burning, so as to insure that it shall burn long enough so that the fall of pressure in reservoir A shall have started the outflow of alcohol from the chamber C into the receptacle D, so as to be ignited by the cartridge, after which the alcohol enters the receptacle D at a uniform rate and burns as it enters. After the operation is completed the apparatus may be prepared for another operation by first letting any remaining air escape from the reservoir, then unscrewing the cap P and removing the igniter H, applying thereto a new cartridge *r* and percussion-cap *r'*, and then reinserting the igniter and cocking it, as before described. A fresh charge of combustible liquid is introduced into C before again pumping in air.

My invention is not limited to the use of a liquid hydrocarbon, such as alcohol, as a compressed combustible gas may be used or even a solid combustible material.

My invention may be greatly modified in its practical application, and I do not limit myself to any one means of applying my invention. I prefer the igniting means herein described; but other igniting means may be used—as, for example, an electric fuse.

I claim as my invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. In an automobile torpedo, the combination with means for storing fluid under pressure, an engine driven by such fluid, and means for starting the engine upon the launching of the torpedo, of means for heating the fluid supplied to the engine, and means for starting the action of said heating means adapted to be set in operation by the launching of the torpedo.

2. In an automobile torpedo, the combination with means for storing fluid under pressure, an engine driven by such fluid, and means for starting the engine upon the launching of the torpedo, of a heater in which a combustible is burned for heating the fluid supplied to the engine, an igniter adapted to ignite said combustible, and means set in operation by the launching of the torpedo for operating said igniter.

3. In an automobile torpedo, the combination with means for storing fluid under pressure, an engine driven by such fluid, and a starting-valve for admitting such fluid to the engine on the launching of the torpedo, of a heater in which a combustible is burned for heating the fluid supplied to the engine, an igniter adapted to ignite said combustible,

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and means set in operation by the opening of said valve for operating said igniter.

4. In an automobile torpedo the combination with a compressed-air reservoir, an engine, and means for starting the engine upon the launching of the torpedo, of an igniter adapted to ignite a combustible within the body of stored compressed air, and means set in operation by the launching of the torpedo for operating said igniter.

5. In an automobile torpedo the combination with a compressed-air reservoir, an engine, and a starting-valve for admitting compressed air to the engine on the launching of the torpedo, of an igniter adapted to ignite a combustible within the body of stored compressed air, and means set in operation by the opening of said valve for operating said igniter.

6. In an automobile torpedo the combination with a compressed-air reservoir, an engine, and means for starting the engine upon the launching of the torpedo, an igniter adapted to ignite a combustible within the body of stored compressed air and a fluid-pressure device for operating said igniter adapted to receive compressed air upon the launching of the torpedo.

7. In an automobile torpedo the combination with a compressed-air reservoir, an engine, and a starting-valve for admitting compressed air to the engine on the launching of the torpedo, of an igniter adapted to ignite a combustible within the body of stored compressed air and a fluid-pressure device for operating said igniter connected beyond said valve to receive compressed air upon the opening of said valve.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

FRANK M. LEAVITT.

Witnesses:
E. S. PORTER,
M. ARONSON.

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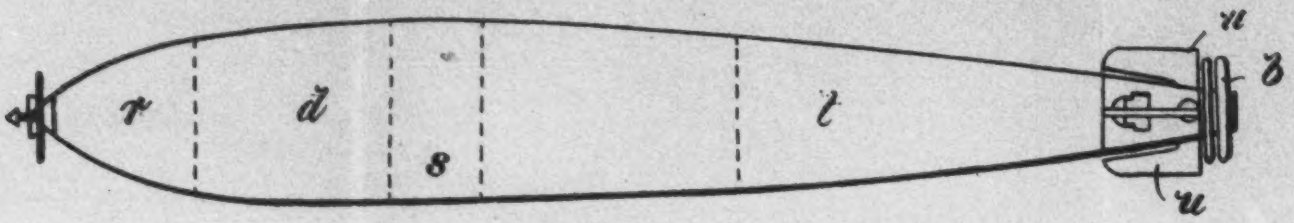
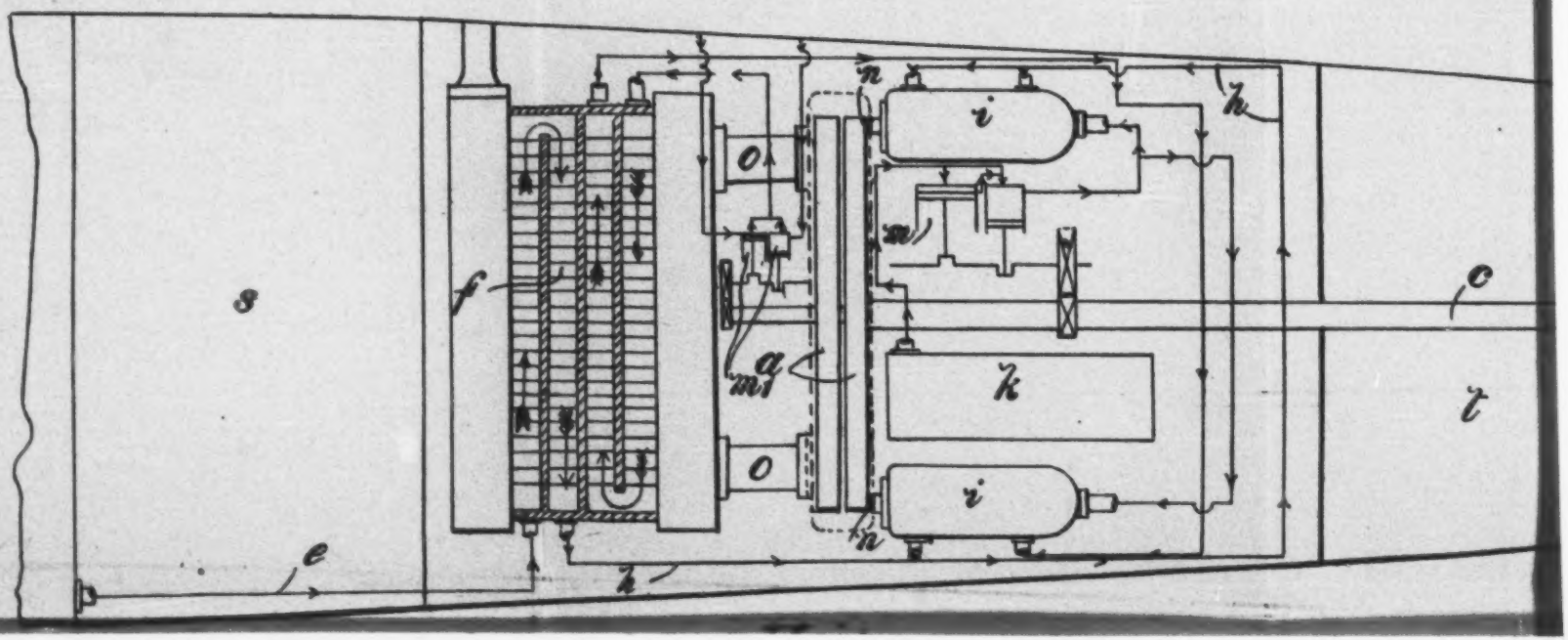


Fig. 1.



A.D. 1904 April 25. N° 9496.
FERRANTI'S Complete Specification.

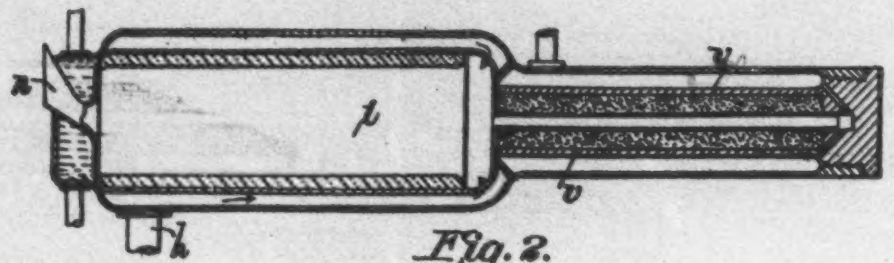


Fig. 2.

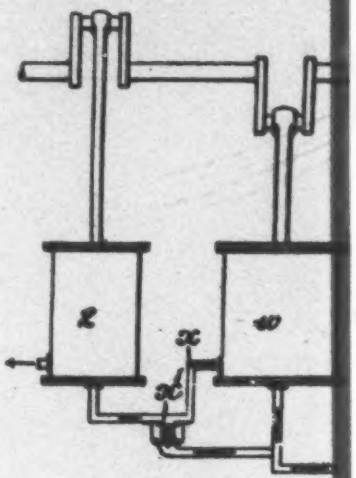


Fig. 3.

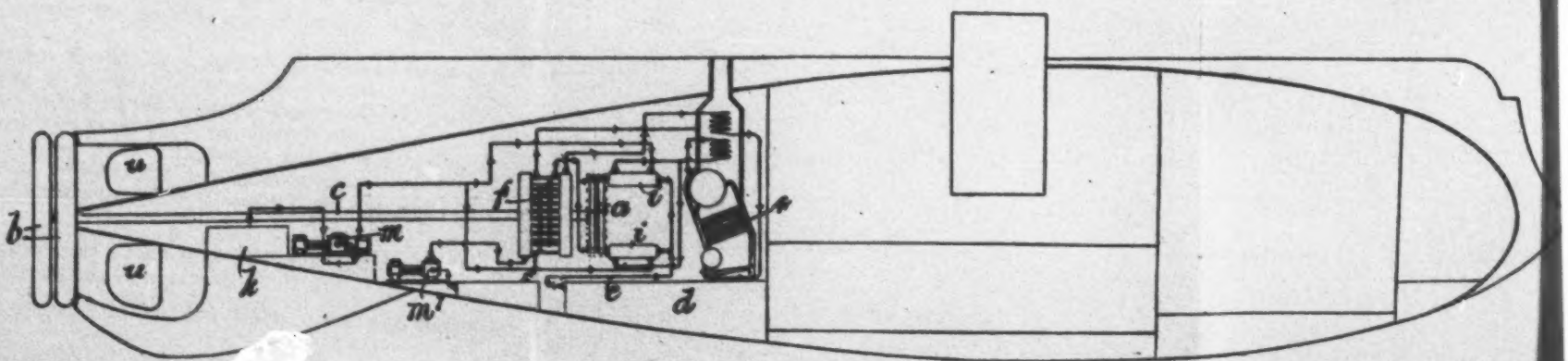
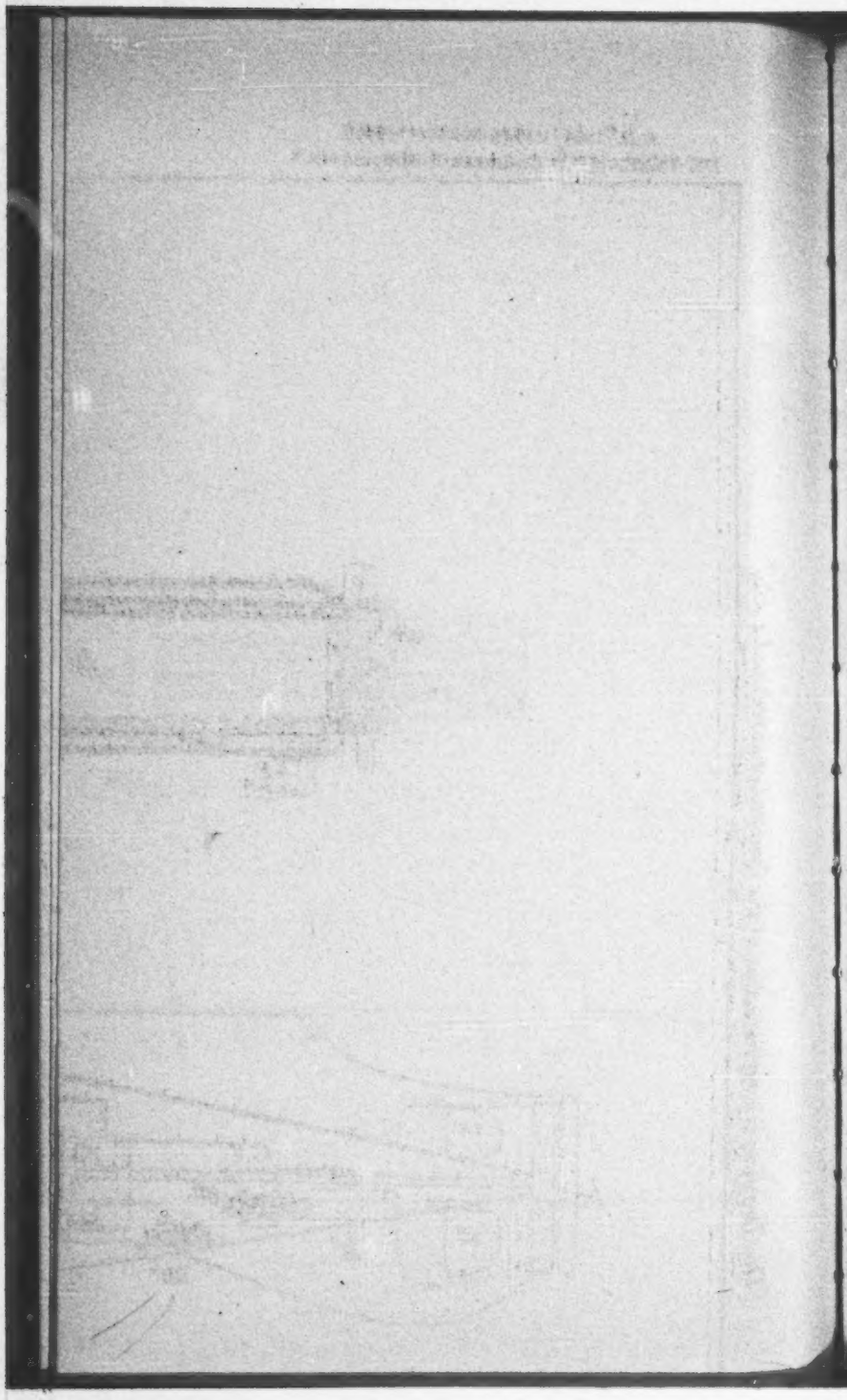


Fig. 4.



simplicity. These may be worked in other respects according to Application No. 1409 of 1904 already filed by me; the difference, however, being that instead of carrying a compressor, they carry a store of air or oxygen in the liquid or pressure form together with sufficient water to form the inert part of the working fluid, the exhaust however after passing through the regenerator being finally cooled in a condenser, so as to recover the water as far as possible for future use in the cycle. By means of carrying compressed oxygen, in which oil is burned and using water, which is dealt with as already explained, I am enabled for the weight carried to get a very large number of horse-power-hours, and by means of a very simple and durable plant to get results much better than can be obtained, as regards weight and the distance travelled, by means of accumulator traction.

Dated this 25th day of April, 1904.

Marks & Clerk, 18, Southampton Buildings, London, W. C., 13, Temple Street, Birmingham, and 30, Cross Street, Manchester, Agents.

Complete Specification

Improvements in and Relating to Turbine Installations for Propulsive Purposes

I, Sebastian Ziani de Ferranti, Engineer and Electrician, of 31 Lyndhurst Road, Hampstead, London, N. W., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:

This invention has for its object to effect improvements in turbine installations so as to make them especially suitable to the propulsion of motor torpedoes, submarine boats, and any boats or vehicles where it is desired to have a simple plant working from stored energy not [fol. 76] only contained in the combustible, but also in the form of compressed air, compressed gas, liquid air or gas, or a compound such as slow burning powders and the like, which are capable of giving off heat energy without the employment of oxygen derived from the external air.

The invention thus consists in a turbine installation adapted to utilise a given store of energy without the employment of oxygen other than that contained in said store in a more efficient manner than has heretofore been possible by any known means.

The invention further consists in certain adjuncts necessary for working the above installation to the best advantage.

Referring to the accompanying drawings which form part of my specification,

Figure 1 is a longitudinal elevation of a Whitehead torpedo driven in accordance with the present invention,

Figure 1a being a section through the engine room to an enlarged scale;

Figure 2 shows a detail of a combustion chamber in which the air is heated by a slow burning powder or the like;

Figure 3 shows an elevation of a special form of pump, while

Figure 4 is a longitudinal elevation partly in section of a submarine driven in accordance with the present invention.

I wish it to be understood that the drawings accompanying this specification are of a diagrammatic nature throughout and are not to be taken as working drawings.

Where desirable corresponding elements in the different figures are denoted by the same reference symbols.

According to my invention, I construct torpedoes of the Whitehead type and instead of fitting them with engines as at present, I supply the motive power by means of a multiple impact turbine having two oppositely running wheels, a, of any known type, which drive screws, b, preferably without intermediate gearing in opposite directions on two concentric shafts, one of which is shown at c. The turbine wheels may be of any of the forms described in a Provisional Application for Patent made by me and numbered 9495 of April 25th, 1904. Instead of feeding these turbines with working fluid in the shape of cold air derived from the storage of compressed air, d, carried in the torpedo, I first lead the air by way of the pipe, e, to the regenerator, f, through which it passes and receives heat from the exhaust from the turbine; thence suitable pipes, h, lead to the combustion chambers, i, in which the air is raised to a high temperature such as 1200° C. or thereabouts by burning in it a small amount of oil or like fuel, for example, stored in a reservoir, k, the fuel being fed by means of a pump, m, driven from the turbine, into the combustion chamber, i, in the form of finely divided spray. The pump is of special construction in order to enable it accurately to supply the charge of oil or the like and will be described later in this specification. The action of the pump may be assisted by feeding the oil to it under pressure derived from the air so as to assist the positive action of the valves and therefore to give an accurate quantity of combustible; to carry this method into effect, it is merely necessary to adapt the oil reservoir to withstand high pressures and to lead a pipe from the compressed air store, d, to the upper part of the reservoir, k. As an alternative the pump, m, may be dispensed with and the oil forced into the combustion chamber entirely by the compressed air. In either case only sufficient oil is delivered to raise the temperature of the working fluid to a point such that after complete expansion, it will not act detrimentally upon the running blades of the turbine. I effect the complete expansion of the fluid in the combustion chamber from a high temperature and pressure down to a little above atmosphere pressure and a temperature of about 400° C. by passing it through the divergent expansion nozzles, n, during its passage through which its pressure energy is converted into kinetic energy. The jets issuing from the nozzles, n, then impinge upon the blades of the turbine wheels and are passed back- [fol. 77] wards and forwards a sufficient number of times to extract

sufficient of this velocity to ensure efficiency. The exhaust from the turbine I prefer to pass through the small regenerator, f, before mentioned by way of the exhaust pipes, o, thus serving to heat the air on its passage from the extra high pressure chamber, d, to the combustion chambers, i. Between the air chamber, d, and the turbine, a reducing valve and control gear such as are usually employed at the present time in Whitehead torpedoes may be fitted; other usual parts of this type of torpedo such as the explosive head, r, balance chamber, s, buoyancy chamber, t, and horizontal and vertical rudders, u, are indicated in Figure 1. It will be seen that on account of the greatly increased efficiency of the arrangement described above over those now in use, I am enabled to considerably reduce the volume of the air chamber, d.

Thus by the means described the compressed air is used on a highly advantageous cycle whereby about four times the horse-power-hours may be obtained in relation to using the air cold according to present practice, the fact of having air under pressure being taken advantage of for this purpose to give an internal combustion turbine of high efficiency.

According to another method I may supply the heat to the compressed air by means of a slow burning powder and I can do this (see Figure 2) by putting a charge of slow powder or like material, which may or may not contain a predetermined amount of water, into a tube or case, v, such as that containing a rocket, but of sufficient strength to resist the full pressure of the cycle. The end of this tube adjoins or projects into the heating chamber the hot gases from it mixing with the air flowing in from the jacket, as indicated by the arrows and heating it to the desired temperature. The mixture is then expanded in the nozzle and dealt with as above explained.

According to another method I replace the storage of compressed air by a storage of compressed oxygen. This when heated by burning in it oil or other suitable combustible, gives a much larger amount of energy than the air. On the other hand, the temperature given is very high, and the result from this combination is too small a quantity of high temperature working fluid to be capable of useful application. It is therefore essential with this method to introduce sufficient medium, which may be of an inert nature, to give the full amount of working fluid at a temperature not exceeding that which can be usefully dealt with that it is possible to get from the weight of oxygen and oil which can be carried. I accomplish this by means of introducing a fixed quantity of water, and mixing, evaporating and superheating this so as to produce the desired result. According to this method I let the discharge from the turbine wheels issue at the full temperature which these will stand for a short period. I pass this exhaust through a regenerator which is so arranged as to efficiently transmit its heat to the water to be used in the cycle. This regenerator in reality forms a partial boiler, as there is sufficient heat contained in the exhaust to heat the whole of the water up to the boiling point, and to evaporate about one-third of the whole at the working pressure. The water is forced through the regenerator

chamber at a high pressure, preferably twice that of the working fluid in the combustion chamber. It is then discharged by means of spray nozzles into the combustion chamber where it is atomised due to the high velocity of issuing through small orifices, and also due to the heat which it contains, which is sufficient to break it up into steam and so intimately mix it with the gases that complete evaporation takes place.

The heat contained in the water under pressure is sufficient to vaporise a portion of it. The steam thus formed internally atomises the remaining water most effectually thus greatly assisting complete evaporation by the hot gases and final mixture therewith.

This method may also be advantageously employed in the cycle when the heat is derived from slow burning powder or similar source of energy.

[fol. 78] The above cycle is generally similar to that described in my Patent Specification No. 13199/03, with reference to Figure 7, similar apparatus modified to meet the new conditions being employed to carrying it into effect. It will, however, be seen that whereas in my Specification, No. 13199/03, a compressor is needed as part of the complete plant, thereby giving rise to considerable negative work and loss of efficiency, in the present invention, this loss is done away with so far as the running of the torpedo is concerned, the whole object of my invention being to utilise a given store energy to the greatest advantage so that in the case of a torpedo, for example, a much greater range may be obtained for the same weight of working fluid or the same range as at present with a reduced weight of fluid.

According to a modification of this form of operation I may use a circulating pump attached to the evaporation chamber which is arranged to catch any liquid which falls therefrom and to force it, together with the rest of the water in the form of spray, again into the combustion chamber. This method is adopted in case the vaporisation of the water is not completed at the first passage into the heating chamber.

According to another method I may mix the water with the oxygen or with the oxygen and the oil, and force these into the combustion and evaporating chamber so that an intimate gas and spray mixture is formed which burns with a temperature not exceeding the maximum at which it is desired to work.

According to another method, instead of using liquid combustible I may store gas under pressure in a separate reservoir, to be burnt with the air or oxygen. Any suitable gas such as coal gas or enriched water gas may be used, or acetylene stored under pressure or stored under pressure in connection with being dissolved in acetone, in much the same way as has been employed for train lighting. In the case of both the combustible when in the form of gas and of the air or oxygen, I store these separately at high pressure and use suitable reducing valves which gives an approximately constant pressure in the working chamber.

I may apply the system where water is introduced and used as described, to motors in which the energy is obtained from stored air

under pressure, and oil or other fuel. In this case the full amount of fuel which the air will burn is introduced, and which without the addition of inert material would give too high a working temperature to be usefully employed. As seen in Figure 1, the water is pumped through the regenerator in parallel with the air by the pump m^1.

According to another method I may combine the above systems in the form of supplying the heat energy from a slow burning powder or material which contains its own elements of combustion and the inert body in the form of water pumped in as already described to the heating chamber. According to this last method I may pump the water through or around the chamber containing the slow burning powder or the like, so as to prevent any undue rise of temperature by transmission from the burning material.

Where the slow burning material can be supplied in the form of liquid, I prefer to mix the water with this and spray into the combustion chamber so as to get the most intimate possible mixture of the burning gases with the water, so as to obtain complete evaporation.

Where I use air or oxygen or the like as part of the motive fluid, I may carry this in the liquid form either in a vessel incapable of standing much pressure in which gas will be given off to the atmosphere due to evaporation, or in a vessel which will stand the full working pressure of the cycle, said pressure being used to force out a sufficient quantity of the liquid for vaporisation under pressure and use in the cycle. Where the liquid is contained without being under much pressure it is necessary to force it by means of a pump for the purpose of evaporation, and use in the cycle. The liquid may be evaporated in one part of the regenerator as above explained, the [fol. 79] other part being used for the purpose of raising the temperature and evaporating the portion of the water which is used as the inert medium. Or on the other hand, the exhaust gases may first heat up and evaporate the water and still contain sufficient heat energy to usefully vaporise the liquid to be converted into gas as already described.

Where I desire to keep such a store of liquid oxygen, liquid air or the like with the minimum vaporisation, I use the gas given off by the same to pass round a jacket adjoining the chamber containing it, for the purpose of keeping down the conduction of heat to the store from the external air or surroundings: in other words, this evaporation is used as a refrigerator to keep down the temperature.

It is obvious that modifications of the above class of operations may be introduced, and I do not confine myself to the exact methods which I have described herein. What, however, is common to all these methods is an immensely better use of the store of energy in the torpedoes than is practicable according to present methods, the turbine being specially useful in the form which I have described for taking advantage of the high temperatures which would be unworkable in an ordinary engine, as it is able to convert these temperatures into velocity and so work with medium temperatures on the moving parts.

The apparatus required to carry into effect the various modifica-

tions I have described is similar to that used in the various cycles of my Patents, Nos. 13199/03 and 1409/04; the operations of these cycles will be readily understood without further explanation in view of the detailed description given above with regard to Figure 1.

Where it is desired to deliver an accurate quantity of liquid, such as to the combustion or evaporation chamber of the turbine, in order to carry the working cycle into effect to the best advantage, I make a compound liquid pump. The larger or first cylinder, w, (see Figure 3) is made in the ordinary way and delivers through the pipe, x, at say two or three times atmospheric pressure. This has an overflow relief value, x^1. The second or smaller capacity cylinder, 2, has valves seated with strong springs, and water is forced in, following the piston from the first pressure chamber, thus ensuring a full charge per stroke, the surplus passing the relief valve, x^1, and if oil, being returned to the suction as indicated, the strong valve closing springs also prevent slip and an accurate amount of fluid of a predetermined amount is delivered.

I may apply these methods to the driving of the turbines of submarines or submersible boats when they are working under the surface. There are two forms of turbines which I prefer to use in connection with this invention. The first form employs as the working fluid steam superheated by internal combustion, as described in my Application for Patent No. 13199 of 1903.

According to the second method I employ an air internal combustion turbine as described in my Specification No. 1409 of 1904. Both these systems are further described and added to in my Application No. 9495 of April 25th 1904, which specification specially describes the particular form of turbine which I consider most suitable for application in the present case.

According to the first method, (see Figure 4), I may carry a store of compressed air, d, or preferably compressed oxygen. I also carry liquid combustible, k, preferably in the form of oil. In some cases I may also carry hot water at high temperature and pressure in insulated storage tanks or vessels; or I may so construct the boiler, 4, with sufficient extra water space to effect the same purpose. Where water is carried hot under pressure in the boiler or separate tank, I prefer to work the boiler at about 50% higher pressure than that at which steam is used in the internal superheating chamber, adjoining the turbine. The extra water carried may be used below the surface to give off steam which will be superheated by means of internal combustion as already described before being passed to the expanding nozzles. In some cases I may simply draw the hot water under [fol. 80] pressure from the store which is carried and use this, which will partially flash into steam in the combustion chamber atomised so as to mix most completely with the burning gases and pass into the nozzle in the form of highly superheated steam and products of combustion. In some cases I simply obtain the necessary heat from the compressed air or oxygen and oil which I carry in the boat, pumping water at high pressure through the regenerator and into the combustion and superheating chamber, the evaporation being thereby effected as already explained in the above cases referred to;

in all these cases the store of compressed fluid takes the place of the compressor in my previous patents above referred to.

The above arrangements are all for working under water but may also be used just before going under water or for running short distances on the surface where it is desired to emit no smoke from the boilers, which should be oil fired.

In some cases it may be advantageous to work boats of this class when using this cycle of operations, by means of compressed air obtained from a running compressor when on the surface, the power provided in the compressor being greater than would be required in the ordinary case and so dispensing with a separate boiler. In this case, the regenerator is made of ample capacity and the water pumped through it, during which operation, sufficient heat is given to raise the whole of the water to boiling point and also to evaporate one-third; this cycle has already been referred to as similar to that above described with reference to Figure 7 of my Patent Specification, No. 13199/03. This disposition of parts greatly assists in atomising the water when it is driven into the combustion chamber and obtaining a mixture so intimate with the burning gases that complete evaporation is obtained. The compressor according to this arrangement of parts is preferably driven from the turbine through a clutch, so that it may be disconnected for working under water and the store of air compressed by it utilised.

According to this method of operation, additional power can be obtained from the cycle by means of allowing the exhaust, consisting of steam and products of combustion, to evaporate water which is used in a condensing turbine, as described in my Patent Specification No. 13199/03, the evaporation taking place at or about atmospheric pressure. In this case it is desirable to instal- the turbines worked in this way on the main propeller shafts, so that the additional power may be obtained under water.

According to the second method, where I employ an internal combustion turbine such as I have already described in my various applications for patents mentioned herein (for example, No. 1409/04) for running on the surface, I may use the methods already described for under-water working. Thus when on the surface, the combustion chambers are fed with air from the compressor, while when below the surface, the compressor is preferably stopped—e. g., by unclutching it, if driven from the turbine—and the combustion chambers fed direct from the store. Either a separate set of chambers and nozzles is provided for the two methods of working or else the same combustion chambers are used in both cases. Suitable valves and connections of any known type are provided for rapidly changing the operation of the turbines from the simple air oil cycle for surface working to that in which air or oxygen previously stored and oil are used for under-water working, water being added in the case of stored oxygen as already fully explained above.

I may modify the above second method of operation by driving as a simple air turbine above water as already explained in which case sufficient air is compressed not only to burn the combustible but also to act as the inert matter to utilise properly the heat gen-

erated or I may draw a portion of the fluid to be compressed from the outside air sufficient for complete combustion, the balance of the working fluid being drawn from the exhaust after passing through a final cooler and after compression to the maximum pressure.
[fol. 81] For below water working the only change necessary is to replace the fresh air of the working fluid by air drawn from the pressure storage tanks or from a store of liquid air carried or by oxygen sufficient to burn the fuel, this oxygen being obtained either from cylinders of compressed gas or from a storage of more or less pure liquid oxygen carried in the vessel.

The advantage of this modification of my second method is that no supplementary or different combustion chamber and nozzle arrangements are required for under water working, the valve which cuts off the fresh air supply to the compressor being connected to open out the supply from the storage system. Supplementary compressing cylinders may be fitted to the ordinary working pumps or compressors according to the first and second methods in order to raise the air to storage pressure whilst working on the surface ready for operation under the surface.

The object of my methods of driving submarine or submersible boats is to enable the boat to be so fitted that the same driving mechanism which propels it on the surface is able to be used with the highest possible economy below-water in relation to the amount of propelling material which is stored and carried in the boat for under surface working.

In order that some idea of the improved results likely to accrue from the use of my invention may be realised, I give here certain approximate relative figures for the case of a torpedo.

Thus, taking first the case of an ordinary Whitehead torpedo, I assume a certain definite weight is available for the store of compressed air and the metal shell or envelope containing it, and I represent the number of horse-power-hours obtainable from this weight by unity.

Then with the same weight available in each case;

(1) Using oil and excess of air injected into the combustion chamber, as described in my Application No. 1409/04, I obtain the comparative figure 4.6 as representing the number of horse-power-hours obtainable.

(2) Using oil and just sufficient air for combustion and water raised to the boiling point in the regenerator before injection into the combustion chamber, I obtain the figure 8.6.

(3) Using oil and just sufficient oxygen for combustion together with water, all of which is raised to the boiling point in the regenerator and 37% evaporated therein, I obtain the figure 30.2.

(4) Using the same media as in (2) but carrying the air in the liquid state, I obtain (a) with a double casing for the air, i. e., a refrigerating jacket as described above, the figure 18 and (b) with a single casing, the figure 25.1.

(5) Using the same media as in (3) but carrying the oxygen in the liquid state, I obtain (a) with a double casing i. e., a jacket, for the oxygen, the figure 52.5 and (b) with a single casing, the figure 69.6.

The methods which I have described are such as to give great economy and therefore to give the largest number of horse-power-hours for the weight of stored material which is carried. A further great advantage in relation to other methods is that maximum horse-power may be obtained for moderate periods of time in running under water; or on the other hand the storage by this method and special adaptation to the turbine may be so used as to give considerably more than the surface working maximum for short periods of increased speed under water.

I may also use the same methods of operation for the propulsion of motor cars or other vehicles where it is desired to obtain great simplicity. These may be worked in other respects according to Application No. 1409 of 1904 already filed by me; the difference, however, being that instead of carrying a compressor, they carry a store of air or oxygen in the liquid or pressure form together with sufficient water to form the inert part of the working fluid, the exhaust, however, after passing through the regenerator being finally cooled in a condenser, so as to recover the water as far as possible [fol. 82] for future use in the cycle. By means of carrying compressed oxygen, in which oil is burned and using water, which is dealt with as already explained, I am enabled for the weight carried to get a very large number of horse-power-hours, and by means of a very simple and durable plant to get results much better than can be obtained, as regards weight and distance travelled, by means of accumulator traction.

Although I have described three ways in which my invention may be carried into effect, viz., for driving torpedoes, submarines and submersibles, and road vehicles, I wish it to be understood that what I have described above as applying to one of the above may in some cases be applicable to another, and in the appended claims I have used the word "automotor" in its generic sense to include any or all of the above applications.

I also wish it to be understood that by the term "internal combustion turbine," I intend to include only those cases in which the energy derived from the combustion of the fuel is imparted to the working fluid previous to or during its expansion in the fixed parts of the turbine and not on its passage through the blades.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In an automotor, the use of a turbine fed from energy stored in fuel such as oil or gas under pressure and an oxydiser such as air or oxygen stored under pressure or in liquid form, substantially as and for the purpose described.

2. In an automotor such as claimed in Claim 1, adding to the working fluid inert matter such as water carried in a storage tank

or pumped in from the outside, substantially as and for the purpose described.

3. In an automotor such as claimed in Claims 1 or 2, adding inert matter to the cycle in the form of exhaust products, substantially as and for the purpose described.

4. An automotor turbine driven boat which when working on the surface uses air pumped from the outside and which when under water uses stored air, oxygen or like oxydiser to burn the fuel used in the cycle, substantially as described.

5. In an automotor boat such as claimed in Claim 4, adding inert matter to the working fluid in the form of water or of products of combustion, substantially as described.

6. In a turbine driven automotor, supplying the working fluid by the burning of self-oxydising combustible such as slow burning powder, the gases from which are expanded through nozzles and form the working fluid, substantially as and for the purpose described.

7. In an automotor such as claimed in Claim 6, adding inert matter to form part of the working fluid, substantially as and for the purpose described.

8. In automotors such as previously claimed, the use of a regenerator for one or more of the elements forming the working fluid, substantially as and for the purpose described.

9. My improvements in the driving of automotors, substantially as hereinbefore described.

Dated this 27th day of February, 1905.

Marks & Clerk, 18, Southampton Buildings, London, W. C. 13, Temple Street, Birmingham, and 30, Cross Street, Manchester, Agents.

[fols. 83-88] EXHIBIT C-6—Omitted in printing

(Here follow side folio pages 89-93)

No. 835,262. PATENTED NOV. 6, 1906.

W. H. SODEAU.

MEANS FOR HEATING COMPRESSED GAS.

APPLICATION FILED AUG. 21, 1905.

Fig. 1.

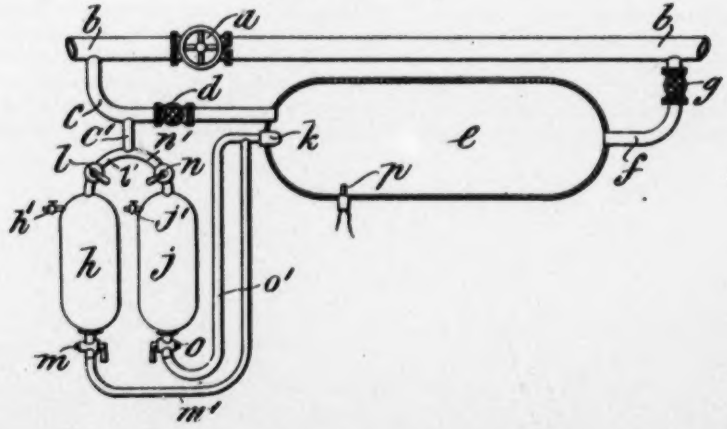


Fig. 2.

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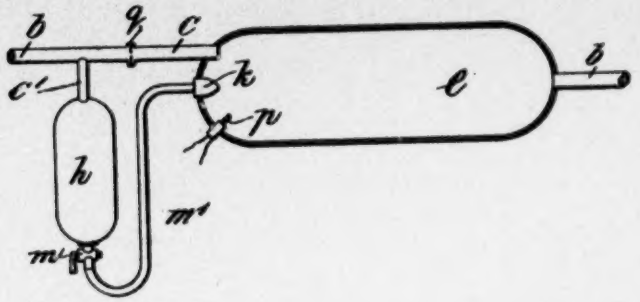
Fig. 2.



Witnesses
K. H. Fanning
C. J. Early

Inventor.
W. H. Sidearis
By his attorneys
Baldwin & Wight.

C-7
To Court's findings

Pages 89-90

supply pipe *b* and the combustion-chamber *e*,

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UNITED STATES PATENT OFFICE.

WILLIAM HORACE SODEAU, OF NEWCASTLE-UPON-TYNE, ENGLAND, ASSIGNOR TO SIR W. G. ARMSTRONG, WHITWORTH & COMPANY LIMITED, OF NEWCASTLE-UPON-TYNE, ENGLAND.

MEANS FOR HEATING COMPRESSED GAS.

No. 835,262. Specification of Letters Patent. Patented Nov. 6, 1906.

Application filed August 21, 1905. Serial No. 275,029.

To all whom it may concern:

Be it known that I, WILLIAM HORACE SODEAU, engineering chemist, a subject of the King of Great Britain, residing at Elswick Works, Newcastle-upon-Tyne, England, have invented certain new and useful Improvements in Means for Heating Compressed Gas, of which the following is a specification.

It has before been proposed to heat compressed air or gas by means of the combustion in it of petroleum, alcohol, or other suitable combustible liquid, thereby raising the temperature of the air and consequently increasing the volume which a given weight would occupy at a given pressure. The rise of temperature has other beneficial effects, notably that it is capable of preventing the formation of ice from any water which may have been carried forward by the compressed air.

ing the size of the hole or holes in the perforated plate above described or by increasing the orifice through which the combustible liquid is discharged. The same effect is produced by decreasing the pressure, and consequently the density, of the compressed-air supply; but if the mean pressure is kept constant the proportion will be but little influenced by the rate at which the compressed air is passing, as the stream of combustible liquid will vary in practically the same degree. It will thus be seen that within reasonable limits any desired temperature can be obtained by altering the mean pressure or by changing the arrangement producing the drop in the air-pressure or by changing the fuel-delivery orifice.

When only a moderate rise of temperature is desired, as in the case of pneumatic hand-tools, &c., only a portion of the total air-sup-

of which the following is a specification.

It has before been proposed to heat compressed air or gas by means of the combustion in it of petroleum, alcohol, or other suitable combustible liquid, thereby raising the temperature of the air and consequently increasing the volume which a given weight would occupy at a given pressure. The rise of temperature has other beneficial effects, notably that it is capable of preventing the formation of ice from any water which may have been carried forward by the compressed air.

According to this invention the combustion takes place inside the pipe or passage through which the compressed air is supplied to the engine or pneumatic tool, which pipe or passage will usually be locally increased in diameter in order to provide a combustion-chamber of sufficient capacity and suitable shape, and the arrangement is such that the ratio of fuel to air can be kept practically constant or can be varied at pleasure.

The combustible liquid is contained in an appropriate vessel or fuel-reservoir communicating with the compressed-air-supply pipe at a point where the pressure is higher than in the combustion-chamber and connected to a pipe passing into the combustion-chamber, where it preferably terminates in a suitable spraying-nozzle.

In some installations there may be an already existing drop of pressure which can be utilized for feeding the combustible liquid into the combustion-chamber; but it is usually necessary to interpose a special obstacle, such as a cock or a perforated plate, in the path of the compressed air.

The amount of combustible liquid fed into the combustion-chamber per unit weight of compressed air will of course depend upon the relative densities of the two fluids and the relative resistances in the paths of each. Thus the relative proportion of a given combustible liquid may be increased by decreasstant the proportion will be but little influenced by the rate at which the compressed air is passing, as the stream of combustible liquid will vary in practically the same degree. It will thus be seen that within reasonable limits any desired temperature can be obtained by altering the mean pressure or by changing the arrangement producing the drop in the air-pressure or by changing the fuel-delivery orifice.

When only a moderate rise of temperature is desired, as in the case of pneumatic hand-tools, &c., only a portion of the total air-supply need be sent through the combustion-chamber, appropriate cocks, valves, or other controlling devices being employed to obtain the desired ratio between the two air-streams which streams are, of course, subsequently reunited.

In installations which are required to run for long periods I preferably employ two or more fuel-reservoirs provided with appropriate cocks or valves so arranged that an empty reservoir may be shut off and refilled without interfering with the continuous action of the appliance. The spray may be ignited by introducing a piece of burning material into the combustion-chamber after temporarily relieving the pressure in the same (appropriate valves, cocks, doors, &c., being provided for this purpose) or while the compressed air is actually traversing the combustion-chamber by means of an ignition-tube, primer, cap, or electric ignition device.

Figure 1 is a diagrammatic sectional elevation of an apparatus suitable for use with pneumatic hand-drills and the like. Fig. 2 is is a milar view of an apparatus suitable for torpedo propulsion.

In Fig. 1 the greater part of the air passes through the cock *a* in the main supply-pipe *b*, by which it is led to the engine; but a portion takes the alternative path through the pipe *c*, which forms a connection between the air-supply pipe *b* and the combustion-chamber *e*,

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and becomes heated and then rejoins the main stream through the pipe *f* and cock *g*.

Liquid fuel is contained in the fuel-reservoirs *h j*, which are connected to the air-supply pipe *b* by the pipes *c c'* and *l'* and *n'*, the pipes *l'* and *n'* being provided with cocks *l* and *n*. The reservoirs *h* and *j* are connected to the chamber *e* by the pipes *m'* and *o'*, which are provided with cocks *m* and *o*. Fuel may be supplied to the reservoirs through the valved openings *h'* and *j'*.

The drop of pressure caused by the cock *d* causes the liquid fuel to be forced through the spraying-nozzle *k* for combustion in the chamber *e*.

The proportion of fuel to air in *e* may be increased by decreasing the opening of the cock *d*, while the fuller opening of the cock *g* or the partial closing of the cock *a* will cause a larger stream to pass through the chamber *e*. These adjustments enable the desired temperature to be obtained.

When the reservoir *h* becomes empty, it may be refilled after closing the cocks *l* and *m*, the supply of fuel being meanwhile obtained from the reservoir *j*, and the latter can be similarly filled after closing the cocks *n* and *o*. The spray may be ignited by means of an appropriate electric igniter *p*.

In Fig. 2 the portion of the pipe *b* between the pipes *c* and *f*, Fig. 1, is omitted, the pipe *c* being in a line with and forming a continuation of the pipe *b*, so that the whole of the air passes through the chamber *e* and is led away by the pipe *f* of Fig. 1, which is now merged in the outgoing portion of the pipe *b*. In this case the requisite head for spraying is caused by the insertion of a perforated plate *q* in the pipe *c*, through which the whole of the compressed-air stream passes into the combustion-chamber *e*.

When the engine has made a prearranged number of revolutions, the valve *m* is opened by hand and liquid fuel is forced from the reservoir *h* through the nozzle *k* into the chamber *e*. Almost immediately the primer *p* is fired and the spray is thereby ignited. In both arrangements the ends of the pipes *m'* and *o'*, which are connected to the chamber *e*, are preferably at a higher level than the tops of the reservoirs *h* and *j*, so that fuel is only supplied to the chamber *e* when air is flowing through the pipe *b*.

What I claim is—

1. The combination of an air-supply pipe, a reservoir for liquid fuel, a combustion-chamber, connections from the pipe to the reservoir and chamber, a connection from the reservoir to the chamber, and means in the connection from the pipe to the chamber for reducing the pressure of the air-supply to the chamber as compared with that of the reservoir.

2. The combination of an air-supply pipe, a reservoir for liquid fuel, a combustion-chamber, connections from the pipe to the reservoir and chamber, a connection from the reservoir to the chamber, (the chamber end of this connection being at a higher level than the top of the reservoir,) and means in the connection from the pipe to the chamber for reducing the pressure of the air-supply to the chamber as compared with that to the reservoir.

3. The combination of an air-supply pipe, a reservoir for liquid fuel, a combustion-chamber, a connection from the pipe to the reservoir, two connections from the pipe to the chamber, a valve in the pipe between these two connections, a connection from the reservoir to the chamber, and means in one of the connections from the pipe to the chamber for reducing the pressure of the air-supply to the chamber as compared with that to the reservoir.

4. The combination of an air-supply pipe, a reservoir for liquid fuel, a combustion-chamber, a connection from the pipe to the reservoir, two connections from the pipe to the chamber, a valve in the pipe between these two connections, a connection from the reservoir to the chamber, (the chamber end of this connection being at a higher level than the top of the reservoir,) and means in one of the connections from the pipe to the chamber for reducing the pressure of the air-supply to the chamber as compared with that to the reservoir.

WILLIAM HORACE SODEAU.

Witnesses:

OSCAR FREY,

PERCY FREDERICK ALLAN.

P-92

N° 15,997 A.D. 1906

Date of Application, 14th July, 1906

Complete Specification Left, 14th Feb., 1907—Accepted, 11th July, 1907

PROVISIONAL SPECIFICATION.

Improvements relating to the Heating of Compressed Air for use in Motors.

We, SIR W. G. ARMSTRONG & COMPANY, LIMITED, Manufacturing Engineers, and WILLIAM SODEAU, Engineer, all of Elswick Works, Newcastle-on-Tyne do hereby declare the nature of this invention to be as follows:—

This invention relates to improvements in the means used in torpedoes and the like for heating air under high pressure within a closed chamber, such for instance as described in our prior Patent No. 3495 of 1905.

According to the form described in our early patent mentioned above, a combustible, preferably liquid fuel, is mixed with air under pressure from a storage vessel and the heat is used to cause the expansion and prevent undue cooling of the air which forms the working fluid in a motor, *e.g.* the propelling engines of an automobile torpedo.

The object of the present invention is to so improve such means as to give increased safety and reliability in the firing of the fuel and air.

The invention consists in a device of the kind described in which the mixture after being fired automatically at starting the engine is maintained burning in a reliable manner by preventing undue cooling of the flame which takes place owing to the presence of an excess of air supply over that required for complete combustion.

The invention also comprises a heating device for compressed air for use in torpedoes and the like having a fuel tank connected to the air supply and to a combustion chamber into which the compressed air is led from a storage tank through a reducing valve, this combustion chamber being provided with an igniting device comprising a percussion primer or the like directly acted upon by a piston and striker propelled forward by compressed air admitted on opening a starting valve, the air to the striker, the oil to the combustion chamber and the air to the fuel tank being capable of being simultaneously shut off by mechanically-connected cocks when desired.

The invention further comprises the improved arrangement of heating device for use in torpedoes hereinafter described.

In carrying the invention into effect according to one form air from the storage chamber in, say, a torpedo of the Whitehead type, is passed through a starting valve and a reducer into a combustion chamber where it impinges upon a perforated deflecting plate. Into this combustion chamber there is also led any suitable kind of liquid fuel contained in a tank subjected to an air pressure greater than that which obtains in the combustion chamber. Thus, according to one form the air space in the fuel tank may be connected direct to the reducer while any suitable construction such as a cock or perforated plate may be interposed in the pipe leading from the reducer to the combustion chamber. At any suitable point, as for instance in the pipe connection between the starting valve and the reducer a supply pipe is led to a striker device attached to the combustion chamber. This striker device is arranged to act directly upon a percussion primer containing preferably a slow burning composition. A preferred construction of igniting device is as follows:—

The percussion primer is placed in an appropriate holder in the outer end

of which there is screwed or otherwise held a hollow plug containing a piston. One end of this piston *viz*:—the one nearest the primer is tapered as in an ordinary percussion striker. The piston is up to the moment of firing kept at the further end of the cylinder by means of a spring, spring catch, shearing wire or any other appropriate device. The cylinder is, of course, formed in the most convenient way for extracting the primer. The air supply pipe to the striker leads into the cylinder behind the piston. In this way when the starting valve is opened air at high pressure is admitted behind the piston which is thus driven rapidly down the cylinder so that its tapered end strikes the cap of the primer and thus fires it.

In order to prevent excessive or sudden ingress of fuel to the combustion chamber which might on ignition produce an excessive increase in pressure in that chamber, the air supply pipe to the fuel tank is of constricted area while a considerable air space is provided in the fuel tank above the fuel or in a separate vessel connected therewith. In this way the accumulation of air pressure above the fuel is retarded and the starting of the fuel flow into the combustion chamber is somewhat gradual. The air pipe leading to the fuel tank and the fuel pipe leading from the fuel tank to the combustion chamber as well as the air supply pipe to the striker are all capable of being controlled by mechanically connected cocks. This control may be effected either by means of a cock or valve having three separate passages whereby on moving the cock or valve all the passages will be simultaneously controlled or one cock may be employed controlling two of the passages while another controls the third, the cocks being mechanically connected so as to rotate together. Separate cocks may be employed for each pipe.

In order that the combustion may be as complete as possible the air supply should be properly distributed to the flame around the oil nozzle leading into the combustion chamber. When, however, the air admitted to the combustion chamber is very largely in excess of that required for combustion, according to the present invention we direct a portion of the air away from the flame for instance towards the walls of the combustion chamber by means of a perforated deflecting plate while the remainder passes through the perforated screen and unites with the oil issuing through a suitable spraying nozzle.

If desired a number of perforated screens may be employed through which the air is passed before it unites with the oil issuing through the spraying nozzle. Or the air supply pipe to the combustion chamber may be provided with a suitable directing nozzle so as to cause only a portion of the air to come in contact with the flame.

Dated this 14th day of July, 1906.

MARKS & CLERK,
18, Southampton Buildings, London, W.C.
13, Temple Street, Birmingham, and
30, Cross Street, Manchester,
Agents.

COMPLETE SPECIFICATION.

"Improvements relating to the Heating of Compressed Air for use in Motors."

We, Sir W. G. Armstrong Whitworth & Company, Limited, and William Horace Sodeau, Engineers, all of Elswick Works, Newcastle-on-Tyne, in the

in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to apparatus used for increasing the energy of compressed air as used in automobile torpedoes. In such apparatus air is passed to a combustion chamber and some of it is used to support the combustion of a fuel therein, usually a liquid fuel. In some cases, *e.g.*, in our Patent No. 3495 of 1905, only some of the air is led to the combustion chamber.

The objects of the present invention are to effect increased safety reliability and efficiency in a compact air heating device.

The present invention comprises in the first place deflecting means within the combustion chamber introduced into the path of the air flowing thereto and adapted to allow only a portion of the air to pass into the region of active combustion whereas the residue is deflected away from that region preferably towards the walls of the combustion chamber where it effects a cooling of these walls.

In this manner the combustion is maintained in a reliable and efficient manner as the excess air does not cause undue cooling of the flame.

In order to still further ensure reliable and safe action we provide means for effecting a gradual admission of fuel to the combustion chamber at starting, also improved igniting and safety means, but these will be more readily understood from the accompanying drawings in which,

Figure 1 is a diagrammatic view showing the arrangement of a plant in accordance with this invention.

Figure 2 shows a modified form of air deflector:

Figures 3 and 4 illustrate one form of the safety cock arrangement which we employ, Figure 3 being a plan looking from underneath, and Figure 4 being a section on the line A B Figure 3: while

Figure 5 is a section on the line C D, of Figure 3.

In carrying this invention into effect, according to the form shown diagrammatically in Figure 1, and suitable for an automobile torpedo, air from a storage vessel, *a*, enters a starting valve, *b*, by means of a pipe, *c*, from which valve the air passes to a reducing valve, *d*, and thence into a combustion chamber, *e*, through a pipe, *f*. In the combustion chamber just opposite the inlet of the air thereto, there is provided a perforated plate, *g*, which acts as a deflector and also serves to split the air up into several streams. Further this screen assists in affecting a reduction in the air pressure which is used for feeding the fuel to the combustion chamber. From the reducing valve, *d*, there is also led a pipe, *h*, which passes through a valve or cock, *j*, hereinafter called the safety cock, and thence by a pipe, *k*, to a closed chamber, *m*, containing a liquid combustible. The liquid combustible does not entirely fill the chamber, *m*, and from the lower end of the chamber or fuel tank, *m*, there leads a pipe, *n*, to the combustion chamber, *e*, where a spraying nozzle, *o*, is provided, the safety cock, *j*, also controls the pipe, *n*.

In this device much of the air entering the combustion chamber is deflected by the deflector so as to pass down by the sides of the combustion chamber in an annular stream, while a portion of the air passes through the perforations in the deflector plate and supports the combustion of the liquid fuel issuing from the nozzle. By this means the walls of the combustion chamber are kept comparatively cool, while no objectionable excess of air is supplied in the neighbourhood of the ignited liquid fuel, and the flame is thus maintained at a sufficiently high temperature. The fuel supply to the combustion chamber will also be retarded during a short period after the admission of air to the engine on account of the air space provided in the fuel tank. The purpose of this will be more clearly understood hereafter.

The ignition of the fuel issuing from the nozzle, *o*, is effected by means of a

priate holder, *p*, in the outer end of which there is screwed or otherwise held a hollow plug or cylinder, *r*, containing a piston, *q*. One end, *s*, of this piston, *viz.*, the one nearest the primer, 6, may be tapered as in an ordinary percussion striker. The piston is, up to the moment of firing, kept at the further end of the cylinder, *r*, by means of a spring or a spring catch, shearing wire or any other appropriate device may be used. The cylinder is formed in the most convenient way for extracting the primer when it is desired to do so. In the form shown the cylinder, *r*, within the case, *p*, is perforated by holes, 7, at its upper end, through which holes the compressed air from the pipe, *t*, passes. A stop 8, is screwed into the end of the cylinder, *r*, and an outside cover, 9, is screwed over all. In this way by unscrewing the cover, 9, and withdrawing the cylinder, *r*, the primer, 6, may be readily changed.

The air supply passage, *t*, to the striker leads into the cylinder, *r*, behind the piston, *q*. In this way when the starting valve, *b*, is opened compressed air is admitted behind the piston which is thus driven rapidly downwards against the action of the spring, *z*, so that its tapered end strikes the cap of the primer and thus fires it.

Instead of causing the striker to move against a stationary primer the striking pin may be made stationary and the primer arranged to slide.

In order to prevent excessive or sudden ingress of fuel to the combustion chamber, *e*, which might on ignition produce an excessive increase in pressure, in that chamber, the air supply pipe to the fuel tank is of limited area, while a considerable air space is provided in the fuel tank above the fuel or in a separate vessel connected therewith. In this way the accumulation of air pressure above the fuel is retarded and the starting of the fuel flow into the combustion chamber is somewhat gradual.

The safety cock, *j*, Figures 3, 4 and 5, is composed in the form illustrated of two plugs, *u* and *v*, having levers 2 and 3 fixed thereto, said levers being articulated together by links, so that both barrels are moved simultaneously, any other method of articulation may be adopted, however, so long as the three passages, *h*, *n* and *t*, or any two of them are simultaneously controlled. On opening the starting valve it will be seen that no combustion will occur in the chamber, *e*, unless the safety cock, *j*, is opened, and it is impossible to start the fuel supply to the combustion chamber without simultaneously starting the igniter, and in all cases a proper interval occurs between the firing of the igniter and the gradual admission of fuel to the combustion chamber.

During the time in which the safety cock is closed the torpedo may be manipulated in a similar way to those torpedoes working without air heating which manipulation would otherwise cause the firing of the primer and cause fuel to gain access to the combustion chamber.

Instead of a single deflecting plate, *q*, a number of such plates may be employed, or a deflecting nozzle, 4, as shown in Figure 2, may be used. The deflecting nozzle, 4, is so shaped that only a portion of the air is directed towards the burning fuel. In the form shown the holes at the end of the nozzle direct jets of air towards the jet of liquid combustible while the side holes direct the air jet against the walls of the combustion chamber and away from the fuel jet.

It is found in actual practice that the pipes conveying the air and fuel may sometimes give sufficient retardation of fuel without the employment of a special air space in the fuel flask. The air for the striker may be taken from the combustion chamber, engine pipe or fuel flask as alternatives.

The safety cock is sometimes employed to close merely the two passages controlling the fuel supply, in order to save weight and complication.

Many modifications may be made to the details of the apparatus hereinbefore described. Thus the safety cock may be arranged in one barrel, or in two or three; the form of primer may be altered, and the specific means for deflect-

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed we declare that what we claim is:—

1. In an air heating device for use in automobile torpedoes in which air is passed through a combustion chamber and a portion of it burned with fuel in said combustion chamber, means within the combustion chamber and opposite the air inlet thereto for deflecting the surplus air away from the region of the flame and directing the air for combustion towards said region, substantially as and for the purpose described.

2. In an air heating device for automobile torpedoes employing a separate combustion chamber, a deflector such as *g*, over the air inlet to said combustion chamber, substantially as and for the purposes described.

3. In an air heating device of the type herein described for automobile torpedoes and the like, a percussion ignition device having in combination with a fluid operated striker piston and primer, a removable cylindrical liner and cover holding said liner and primer in place, substantially as and for the purpose hereinbefore described with reference to the accompanying drawings.

4. In an air heating device of the type described a safety cock simultaneously controlling any two or all of the following (*a*) the supply of compressed air to the striker, (*b*) the supply of compressed air to the fuel tank, and (*c*) the fuel supply to the combustion chamber, substantially as described.

5. An air heating device for use in automobile torpedoes and the like having the parts arranged and co-operating, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 14th day of February, 1907.

MARKS & CLERK,
18, Southampton Buildings, London, W.C.
13, Temple Street, Birmingham, and
30, Cross Street, Manchester,
Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1907.

[This Drawing is a full-size reproduction of the Original.]

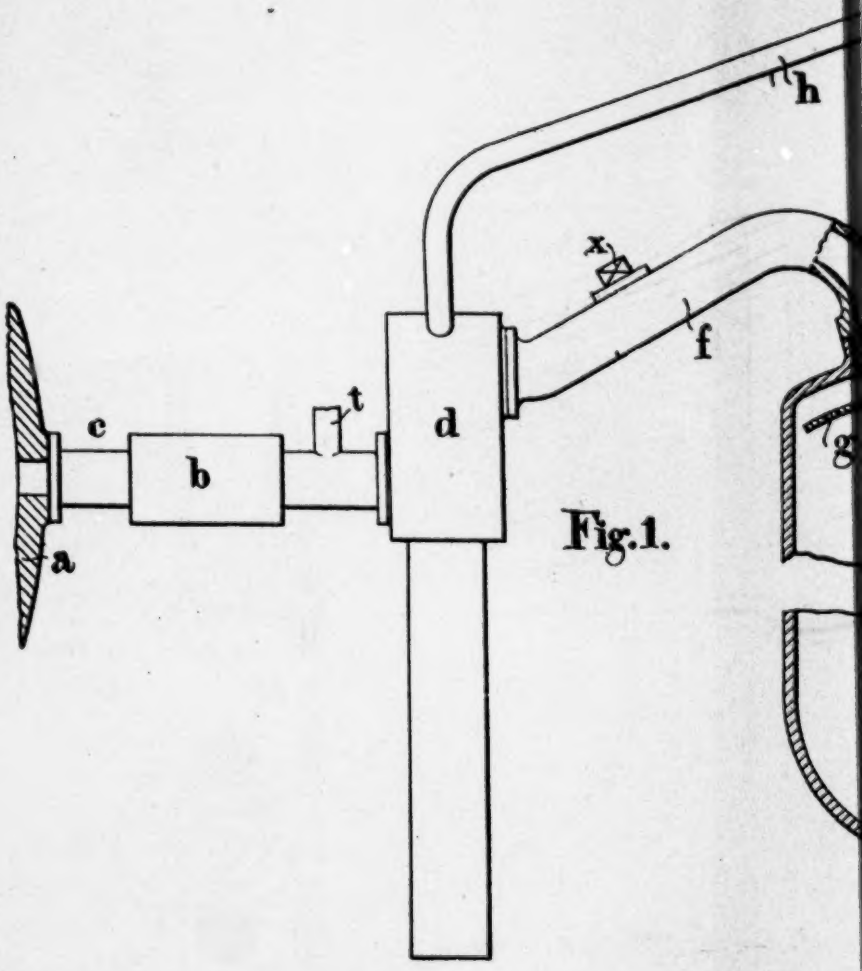


Fig.1.

: 15,997.
& another's COMPLETE SPECIFICATION.

(2 SHEETS)
SHEET 1.

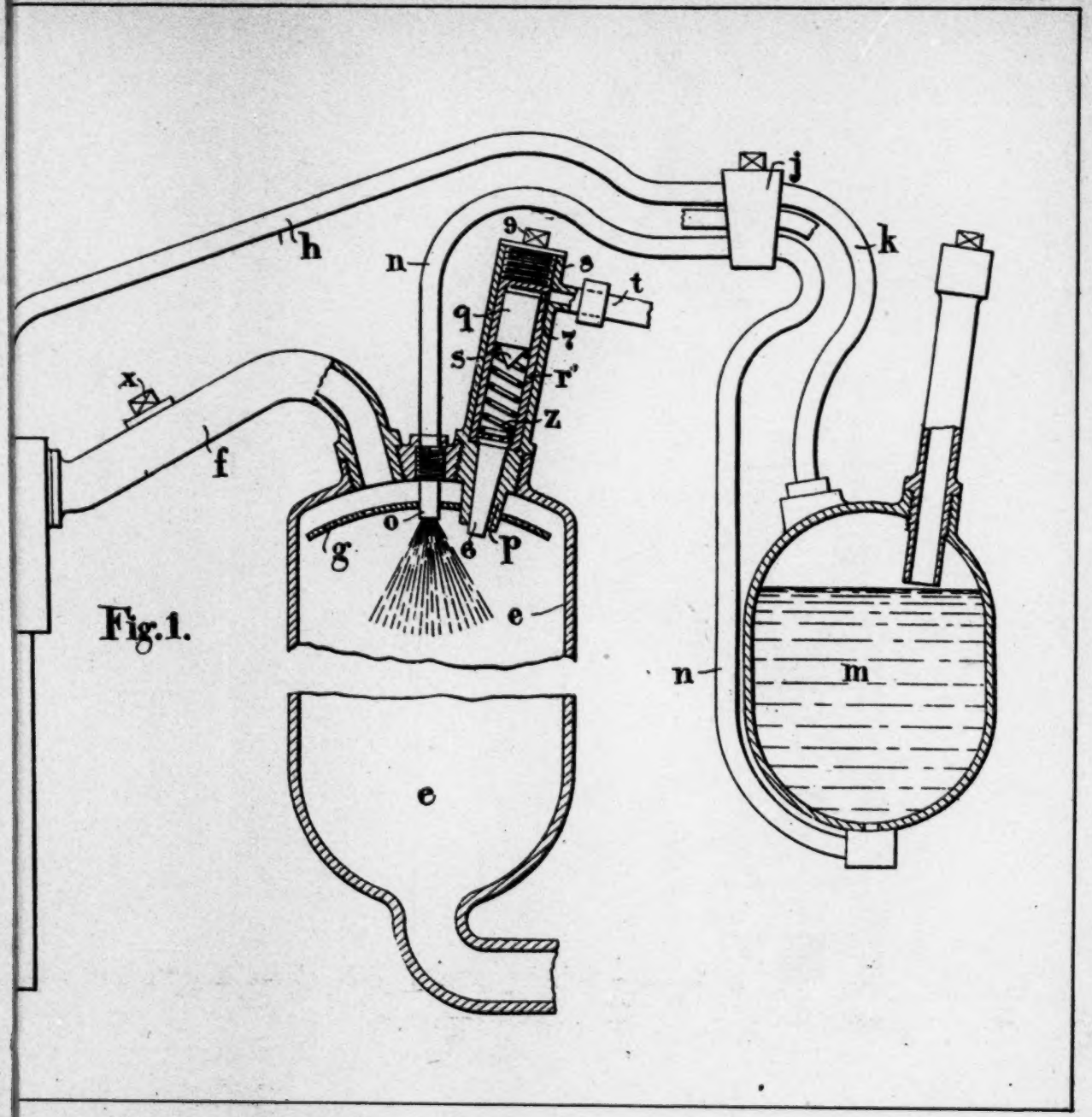


Fig.1.

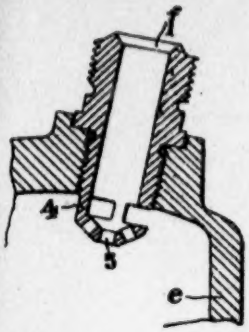


Fig. 2.

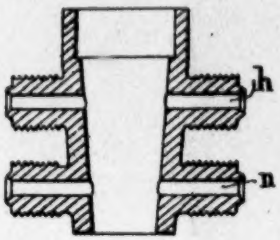


Fig. 3.

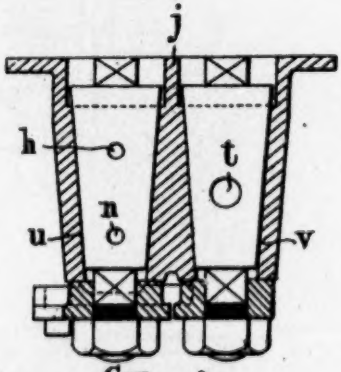


Fig. 4

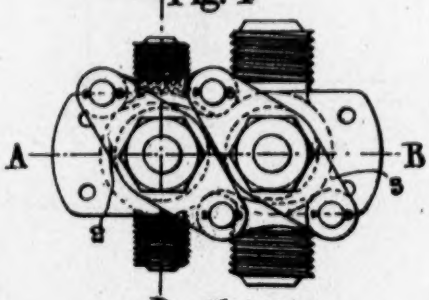
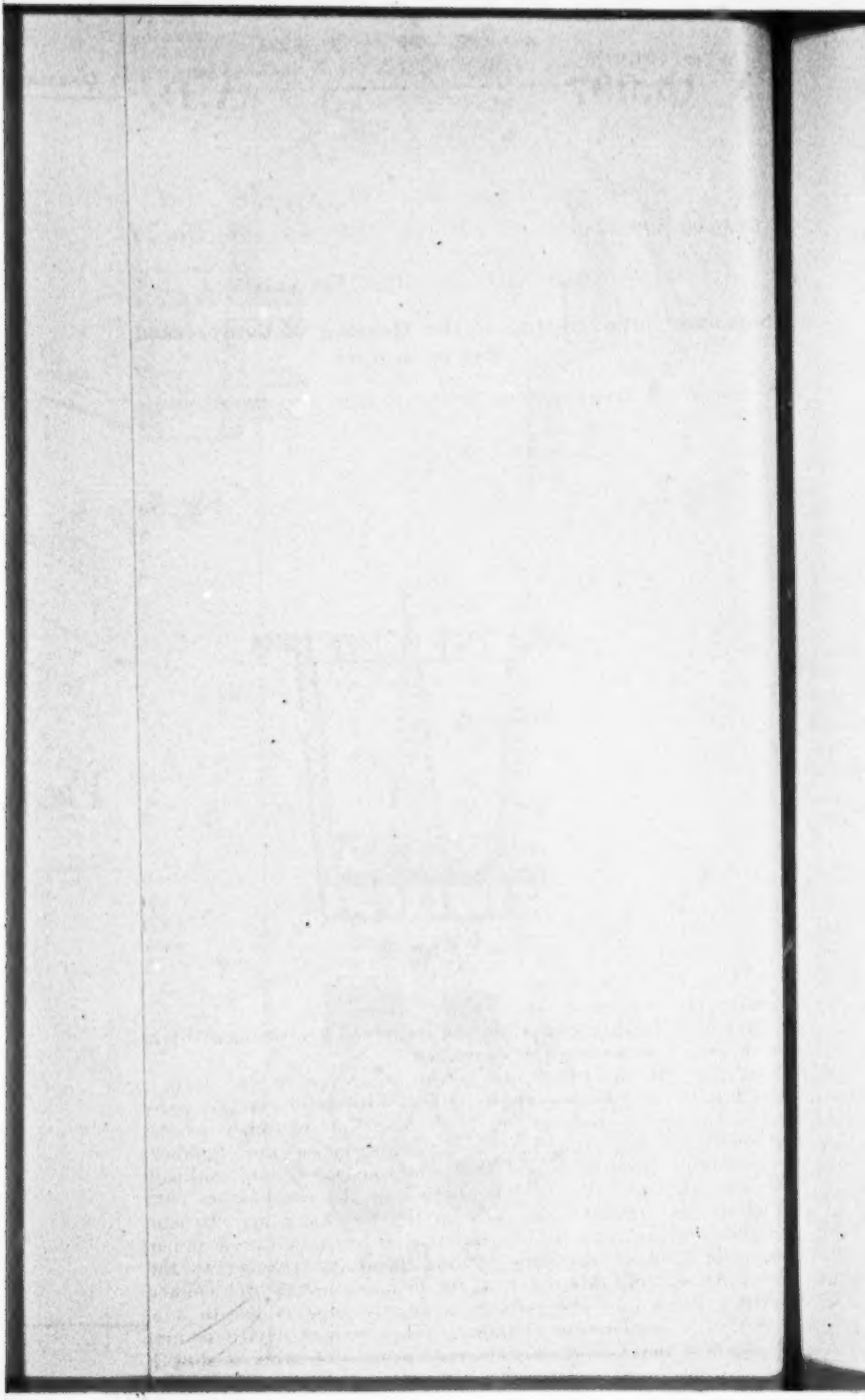


Fig. 5.

Malby & Sons, Photo-Litho.



SIR G. ARMSTRONG, WHITWORTH & CO. & *another's* COMPLETE SPECIFICATION.

P – 104

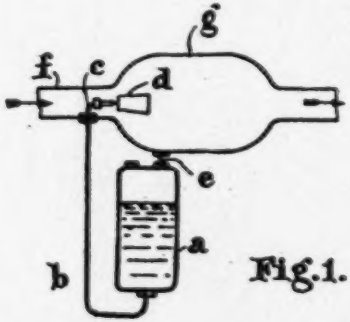


Fig.1.

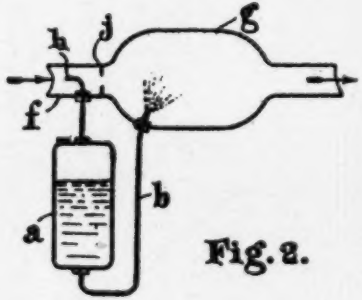


Fig.2.

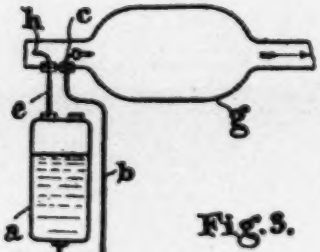


Fig.3.

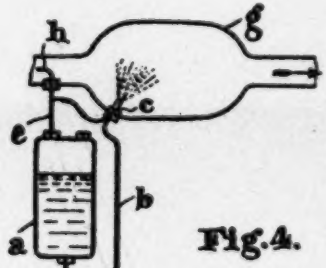
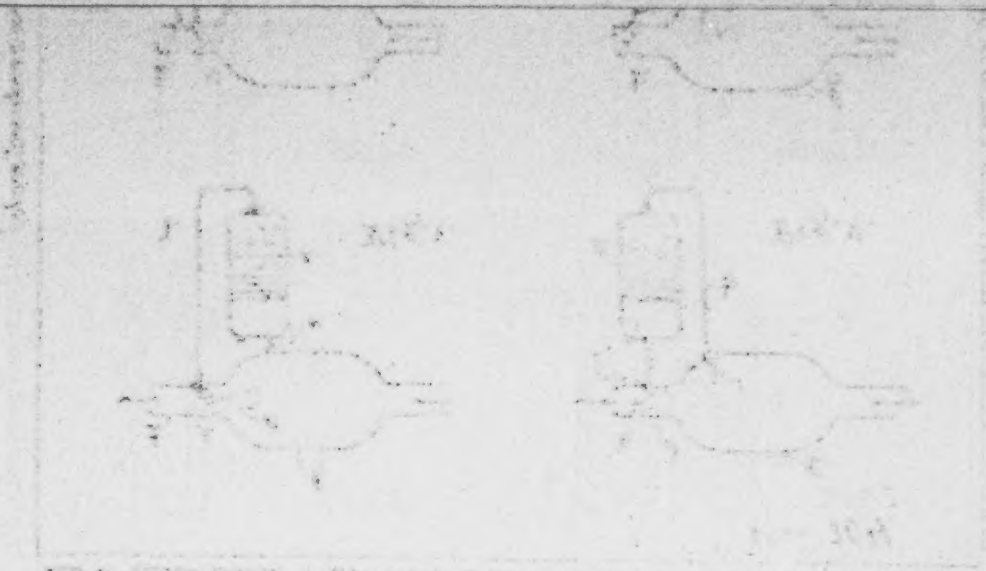


Fig.4.

[Reduced Facsimile of the Original on a reduced scale]

[This Drawing is a reproduction of the Original on a reduced scale.



[fols. 97–103] EXHIBIT C-9—Omitted in printing

(Here follows side folio page 104)

[Matter apparently omitted here.—Printer.]

[fol. 105] centrally at the entrance to the combustion chamber; the air space at the top of the fuel tank may be connected to the combustion chamber itself or by means of a Pitot tube to the air conduit and in addition a scent-spray action may be obtained by providing a cone collector facing towards the stream, this cone collector being arranged to conduct air to the oil spraying nozzle.

Where required, the Pitot action may be assisted by providing a suitable resistance in the pipe such as described in our Patent No. 3495, 1905.

All the above arrangements may also be applied in the case of those forms of heating devices in which water or other appropriate liquid is injected into the products of combustion either directly as a spray or indirectly through a coil or chamber exposed to the heated products of combustion, for the purpose of simultaneously increasing the volume of motive fluid supplied to the engine and reducing the temperature of that motive fluid to a workable amount.

Dated this 12th day of March, 1907.

Marks & Clerk, 18, Southampton Buildings, London, W. C., 13, Temple Street, Birmingham, and 30, Cross Street, Manchester, Agents.

COMPLETE SPECIFICATION

"Improvements in and relating to Means for Increasing the Energy of Stored Compressed Air"

We, Sir W. G. Armstrong, Whitworth and Company, Limited, and Dr. William Horace Sodeau, all of Elswick Works, Newcastle-on-Tyne, in the County of Northumberland; Engineers; do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:

This invention relates to heating apparatus such as used in compressed air plant for heating the air before passing the same to a motor. In such plant it is known to increase the energy of the compressed air by burning therein a liquid fuel. The present in-

vention has particular reference to the means used for feeding the fuel to the combustion chamber, and if so desired water or the like vaporisable liquid into the combustion products for the purpose of reducing the temperature of the same, and at the same time adding to the quantity of working fluid led to the engine.

The object of the present invention is to improve and simplify apparatus of this kind so as to give a simple and automatic adjustment of the fuel, water or like feed in accordance with the density of the air flowing through the combustion chamber or the like and proportional to the quantity or rate of flow of such air.

The present invention consists in means for increasing the energy of stored compressed air comprising means for feeding fuel, water or the like into the compressed air, said feeding means being dependent on the kinetic energy of the air passing any cross section of the pipe leading from the reservoir to the engine.

The means used for feeding comprise a Pitot tube or the like set in the path of the air flowing to the engine either a direct or reverse Pitot action may be employed as in either case the feeding action will be dependent on the kinetic energy of the air stream that is dependent on the square of the velocity of flow and on the density. In- [fol. 106] stead of or in addition to the Pitot tube an ordinary injector action may be employed.

Referring now to the accompanying diagrammatic drawings which show convenient constructions of this invention such as may be applied to the air heating devices used in automobile torpedoes:

Figures 1 to 5 illustrate diagrammatically means the feeding liquid fuel only into the combustion chamber;

Figures 6 and 7 show means for feeding both liquid fuel and water or the like into the air and combustion products respectively.

According to Figure 1, liquid fuel from a tank, a, is led by a pipe, b, to a nozzle, c, within the air conduit pipe, f. The nozzle, c, points in the direction of flow of the air and into an open cone piece, d. A pipe, e, leads from the combustion chamber, g, which is conveniently an enlargement of the air conduit pipe, to the upper end of the fuel tank, a. The air passing through the pipe, f, to the combustion chamber, g, exerts a suction or injection action on the fuel. This suction action is of course proportional to the kinetic energy of the moving stream.

In Figure 2 instead of employing an injector cone, d, we employ a "Pitot" tube, h, set to face the stream of air passing into the combustion chamber, g. In this way, as is well known, a greater pressure than that in the pipe, f, is transmitted to the fuel tank, a, and the difference of the pressures in the pipe, f, and tank, a, in this form is dependent on the kinetic energy of the stream. In many cases it may be found desirable to place some resistance such as a perforated plate, j, in the pipe, f, between the Pitot tube, h, and the combustion chamber, g, as the "Pitot" pressure difference may not be sufficient to effect satisfactorily the feeding. This resistance may however be of any convenient form and in fact the pipe leading to the combustion chamber may be arranged itself to offer a sufficient

resistance for the purpose required. The fuel in the form shown in Figure 3 is led to a spraying nozzle in the combustion chamber.

In Figure 3 the Pitot tube action is employed for collecting the air pressure on the liquid fuel while a reverse Pitot tube is employed for spraying. In this way the Pitot action is increased and in some cases no additional resistance may be required.

In Figure 4 a Pitot tube is employed for collecting the pressure on the top of the liquid fuel and also for collecting air of slightly higher pressure than that in the combustion chamber for the purpose of spraying fuel which is led from the oil tank, a, to the nozzle, c.

In Figure 5 instead of taking the spraying air from the Pitot tube, there is provided a cone, m, which collects the air and helps the oil to spray from the nozzle, c.

In Figure 6 the form of fuel feed illustrated in Figure 3 is employed and in addition to the fuel tank there is provided a reservoir, n, for water, a solution of ammonia salts or the like. The tank, n, is connected by a pipe, o, to a Pitot tube, p, and by a pipe, q, to a nozzle, r, in the combustion chamber, whereby water or the like is sprayed into the products of combustion which not only has the effect of cooling these down to a workable point but also adds to the volume of working fluid passed to the engine. In torpedoes where space is somewhat limited this is a point of considerable importance.

In Figure 7 instead of leading the water or the like from the tank, n, directly into the combustion products it is first led through a spiral, s, placed conveniently in an enlarged portion, t, of the pipe leading from the combustion chamber to the engine. The water or the like is heated while passing through the spiral and is discharged into the combustion products, as indicated at, t, in the form of a vapour or hot liquid.

The feeding of water or the like may of course be aided by means of a resistance in the path of the main air steam as in the case of feeding fuel.

It will be evident that there are many equivalent ways of directly [fols. 107 & 108] using the kinetic energy of the stream flowing to the engine to feed the liquid fuel water or the like into the air or combustion products.

We are aware that proposals have been made to feed fuel or water from a reservoir into a pipe by static pressure; for instance it has been proposed to connect the air space of a water reservoir with an air pipe in front of a reducing valve in the air pipe, and to connect the water space of the reservoir with the air pipe behind the reducing valve, at a point where the pressure is reduced, this latter connection being made by a pipe which enters the casing of the reducing valve and extends a short distance coaxially within the air pipe in the direction of flow of the air therein. The liquid is forced from the reservoir into the air pipe by the difference of pressure which exists between the two sides of the reducing valve. We make no claim however to such arrangements but:

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:

1. In a heating device for stored compressed air, means depending upon the kinetic energy of the air passing a given section of pipe leading said air to the engine for feeding fuel, water or the like into the air or combustion products, substantially as described.

2. In a heating device for stored compressed air for use in a motor, means for feeding fuel, water or the like into the air or combustion products comprising a closed oil tank connected by a tube to a Pitot tube or the like, placed in the current flowing to the motor, substantially as described.

3. Improved means for feeding liquid fuel into compressed air flowing through a combustion chamber or water or the like into combustion products flowing from said combustion chamber, substantially as described and illustrated in the accompanying diagrammatic drawings.

Dated this 14th day of October, 1907.

Marks & Clerk, 18, Southampton Buildings, Chancery Lane, London, W. C., 13, Temple St., Birmingham, and 30, Cross St., Manchester.

(Here follow side folio pages 109-115)

[fol. 116] No. 18,241, A. D. 1908

Date of Application, 31st Aug., 1908—Accepted, 25th Feb., 1909

Complete Specification

Improvements in Apparatus for Increasing the Working Efficiency of Compressed Air and Gas Motor Plants

I, Johann Gesztesy, of Pola, Austria, Imperial and Royal Lineship Lieutenant, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:

Methods of and apparatus for increasing the working capacity of compressed air motors, particularly those employed for automobile torpedoes, have already been described in which the compressed air (its pressure being maintained meanwhile), is mixed with a finely divided liquid fuel and the latter ignited in a special heating chamber, in which a continuous combustion takes place during the working of the motor by the fall of pressure produced thereby. In this method of working the actual quantity of fuel burnt is accurately limited by the introduction of a definite quantity of fuel, below the original pressure of the compressed air, after which the gases of combustion are mixed with steam, which is produced by the introduction

W. H. SODEAU.

MEANS FOR INCREASING THE ENERGY OF STORED COMPRESSED AIR.

APPLICATION FILED JAN. 27, 1908.

964,574. Patented July 19, 1910.

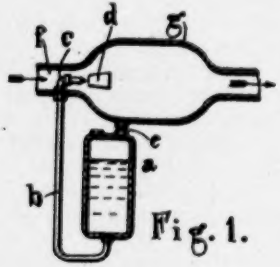


Fig. 1.

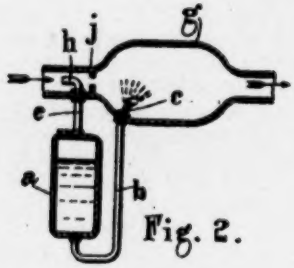


Fig. 2.

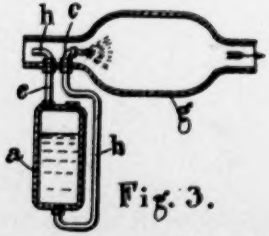


Fig. 3.

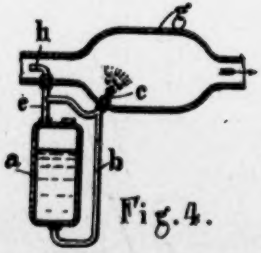
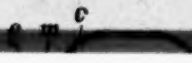


Fig. 4.



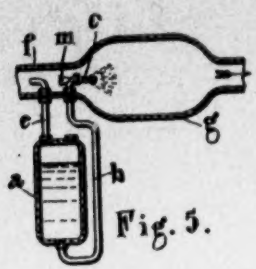


Fig. 5.

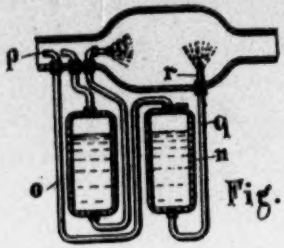


Fig. 6.

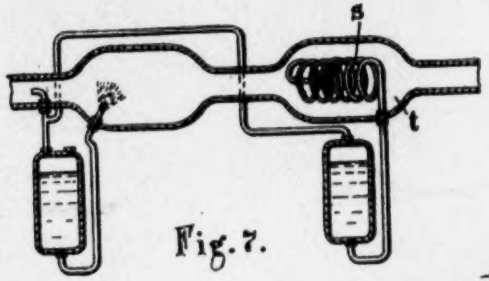


Fig. 7.

ATTEST.
Bert W. Stahl
Edwd L. Tolson.

INVENTOR.
WILLIAM H. SODEAU
By Munn Miller & Donaldson
ATTY'S

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To Court's findings Pages 109-110

UNITED STATES PATENT OFFICE.

WILLIAM HORACE SODEAU, OF NEWCASTLE-UPON-TYNE, ENGLAND, ASSIGNOR TO SIR W. G. ARMSTRONG WHITWORTH & COMPANY, LIMITED, OF NEWCASTLE-UPON-TYNE, ENGLAND.

MEANS FOR INCREASING THE ENERGY OF STORED COMPRESSED AIR.

964,574. Specification of Letters Patent. Patented July 19, 1910.

Application filed January 27, 1908. Serial No. 412,921.

To all whom it may concern:

Be it known that I, WILLIAM HORACE SODEAU, a subject of the King of Great Britain and Ireland, residing at Elswick Works, Newcastle-upon-Tyne, in the county of Northumberland, England, have invented certain new and useful Improvements in Means for Feeding Liquids into Combustion-Chambers, of which the following is a specification.

This invention relates to apparatus such as is used in connection with plant using compressed air for operating a motor or the like. In such plant it is known to increase the energy of the compressed air by burning therein a liquid fuel.

The present invention has particular reference to the means used for feeding the fuel to the combustion chamber, and if so desired water or the like vaporizable liquid into the combustion products for the purpose of reducing the temperature of the same, and at the same time adding to the quantity of working fluid led to the engine.

The object of the present invention is to improve and simplify apparatus of this kind so as to give a simple and automatic adjustment of the fuel, water or like feed in accordance with the density of the air flowing through the combustion chamber or the like and proportional to the quantity or rate of flow of such air.

The present invention consists in means for increasing the energy of stored compressed air comprising means for feeding fuel, water or the like into the compressed air, said means being dependent on the kinetic energy of the air in the pipe leading from the reservoir to the engine.

The means used for feeding comprise a Pitot tube or the like set in the path of the air flowing to the engine—either a direct or reverse Pitot action may be employed as in either case the feeding action will be dependent on the kinetic energy of the air stream that is dependent on the square of the velocity of flow and on the density. Instead of or in addition to the Pitot tube an ordinary injector action may be employed.

Referring now to the accompanying diagrammatic drawings which show convenient constructions of this invention such as may be applied to the air heating devices used in automobile torpedoes; Figures 1 to 5 illustrate diagrammatically means for feeding liquid fuel only into the combustion chamber; Figs. 6 and 7 show means for feeding both liquid fuel and water or the like into the air and combustion products respectively.

According to Fig. 1, liquid fuel from a tank, *a*, is led by a pipe, *b*, to a nozzle, *c*, within the air conduit pipe, *f*. The nozzle, *c*, points in the direction of flow of the air and into an open cone piece, *d*. A pipe, *e*, leads from the combustion chamber, *g*, which is conveniently an enlargement of the air conduit pipe to the upper end of the fuel tank, *a*. The air passing through the pipe, *f*, to the combustion chamber, *g*, exerts a suction or injection action on the fuel. This suction action is of course proportional to the kinetic energy of the moving stream.

In Fig. 2 instead of employing an injector cone, *d*, a "Pitot" tube, *h*, is employed to set to face the stream of air passing into the combustion chamber, *g*. In this way, as is well known, a greater pressure than that in the pipe, *f*, is transmitted to the fuel tank, *a*, and the difference of the pressures in the pipe, *f*, and tank, *a*, in this form is dependent on the kinetic energy of the stream. In many cases it may be found desirable to place some resistance such as a perforated plate, *j*, in the pipe, *f*, between the Pitot tube, *h*, and the combustion chamber, *g*, as the "Pitot" pressure difference may not be sufficient to effect satisfactorily the feeding. This resistance may however be of any convenient form and in fact the pipe leading to the combustion chamber may be arranged to itself offer a sufficient resistance for the purpose required. The fuel in the form shown in Fig. 3 is led to a spraying nozzle in the combustion chamber.

In Fig. 3 the Pitot tube action is employed for collecting the air pressure on the liquid fuel while a reverse Pitot tube is employed for spraying. In this way the Pitot action is increased and in some cases no additional resistance may be required.

In Fig. 4 a Pitot tube is employed for collecting the pressure on the top of the liquid fuel and also for collecting air of slightly higher pressure than that in the combustion chamber for the purpose of spraying fuel which is led from the oil tank, *a*, to the nozzle, *c*.

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In Fig. 5 instead of taking the spraying air from the Pitot tube, there is provided a cone, *m*, which collects the air and helps the oil to spray from the nozzle, *c*.

In Fig. 6 the form of fuel feed illustrated in Fig. 3 is employed and in addition to the fuel tank there is provided a reservoir, *n*, for water, a solution of ammonia, salts or the like. The tank, *n*, is connected by a pipe, *o*, to a Pitot tube, *p*, and by a pipe, *q*, to a nozzle, *r*, in the combustion chamber, whereby water or the like is sprayed into the products of combustion which not only has the effect of cooling these down to a workable point but also adds to the volume of working fluid passed to the engine. In torpedoes where space is somewhat limited this is a point of considerable importance.

In Fig. 7 instead of leading the water or the like from the tank, *n*, directly into the combustion products it is first led through a spiral, *s*, placed conveniently in an enlarged portion, *t*, of the pipe leading from the combustion chamber to the engine. The water or the like is heated while passing through the spiral and is discharged into the combustion products as indicated at *t*, in the form of a vapor or hot liquid.

The feeding of water or the like may of course be aided by means of a resistance in the path of the main air stream as in the case of feeding fuel.

It will be evident that there are many equivalent ways of directly using the kinetic energy of the stream flowing to the engine to feed the liquid fuel water or the like into the air or combustion products.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. Means for increasing the energy of stored compressed air comprising in combination a combustion chamber, a conduit leading compressed air to said combustion chamber, a receptacle for liquid, means leading from said receptacle to said combustion chamber and means connecting said receptacle with the compressed air conduit, said means having an opening in the conduit facing toward the oncoming air whereby the kinetic energy of the air stream in the conduit produces a pressure in the liquid receptacle in excess of that in the air conduit and combustion chamber.

2. Means for increasing the energy of stored compressed air, comprising in combination a combustion chamber, a receptacle for liquid fuel, a jet in said combustion chamber, a pipe leading from said receptacle to said jet, a Pitot tube placed in a passage in which a current of air is flowing, and a pipe leading from said receptacle to said Pitot tube, as and for the purpose described.

3. Means for increasing the energy of stored compressed air comprising in combination a combustion chamber, a passage through which air or gases are flowing, a water receptacle, a pipe connecting between the bottom of said water receptacle and the end of said chamber remote from said air passage, a Pitot tube in said passage and a connection from said Pitot tube to said water receptacle, as and for the purposes described.

4. Means for increasing the energy of stored compressed air comprising in combination a combustion chamber, a conduit leading compressed air to said combustion chamber, a fuel receptacle, means leading from said receptacle to said combustion chamber, and means connecting said receptacle with the compressed air conduit, said means having an opening in the conduit facing toward the oncoming air whereby the kinetic energy of the air stream in the conduit produces a pressure in the fuel receptacle in excess of that in the air conduit and combustion chamber, and a water receptacle, means leading from said water container to the combustion chamber, and means connecting said water container with the compressed air conduit, said means having an opening in the conduit facing toward the oncoming air whereby the kinetic energy of the air stream in the conduit produces a pressure in the water container in excess of that in the air conduit and combustion chamber.

5. Means for increasing the energy of stored compressed air comprising a combustion chamber, a liquid reservoir, a conduit leading air to said combustion chamber and means acting to utilize the kinetic energy of the air stream entering the combustion chamber to produce a greater pressure in said receptacle than exists in said air conduit and means for delivering liquid from the receptacle into the combustion chamber.

6. Means for increasing the energy of stored compressed air, comprising in combination a combustion chamber, a fuel receptacle, a water receptacle, connections from said fuel and water receptacles respectively to said chamber, a passage through which air or gases are flowing, Pitot tubes in said passage, and connections between said Pitot tube and said receptacles.

In testimony whereof, I affix my signature in presence of two witnesses.

WILLIAM HORACE SODEAU.

Witnesses:

STEPHEN MAGUIRE MURRAY,
ROBERT WALLS THOWBURN.

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A.D. 1908 Aug. 31 N° 18,241.
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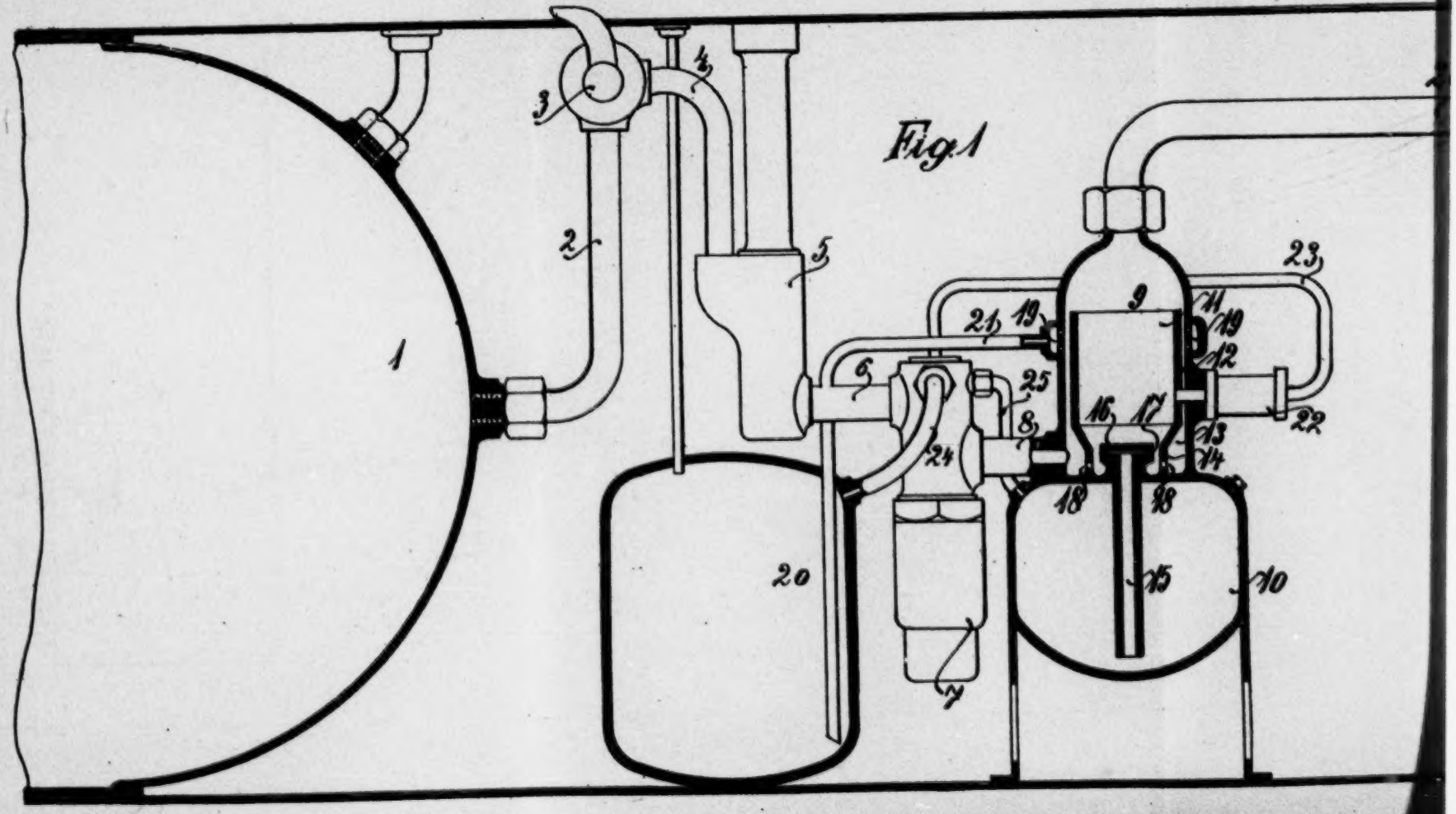

Fig. 1

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Fig. 2

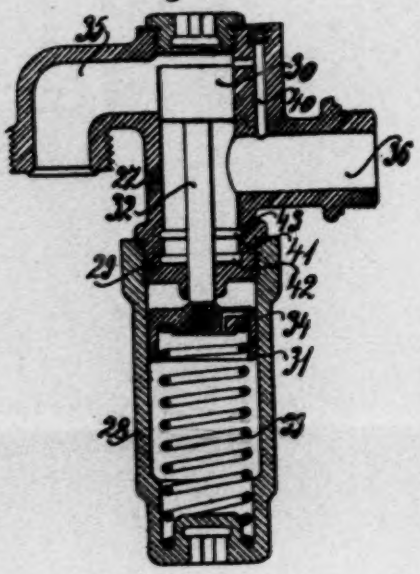

Fig. 4

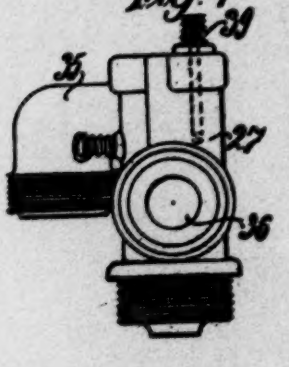

Fig. 5
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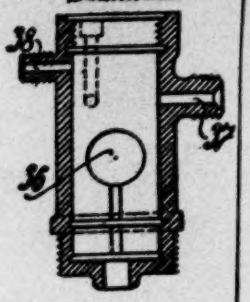
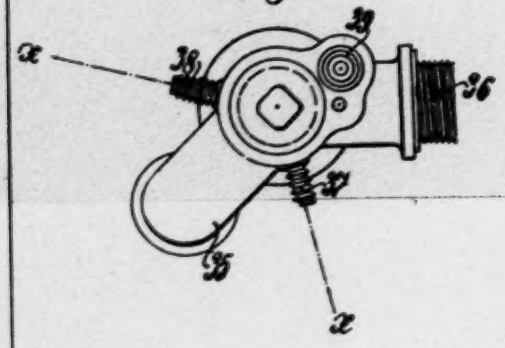


Fig. 3



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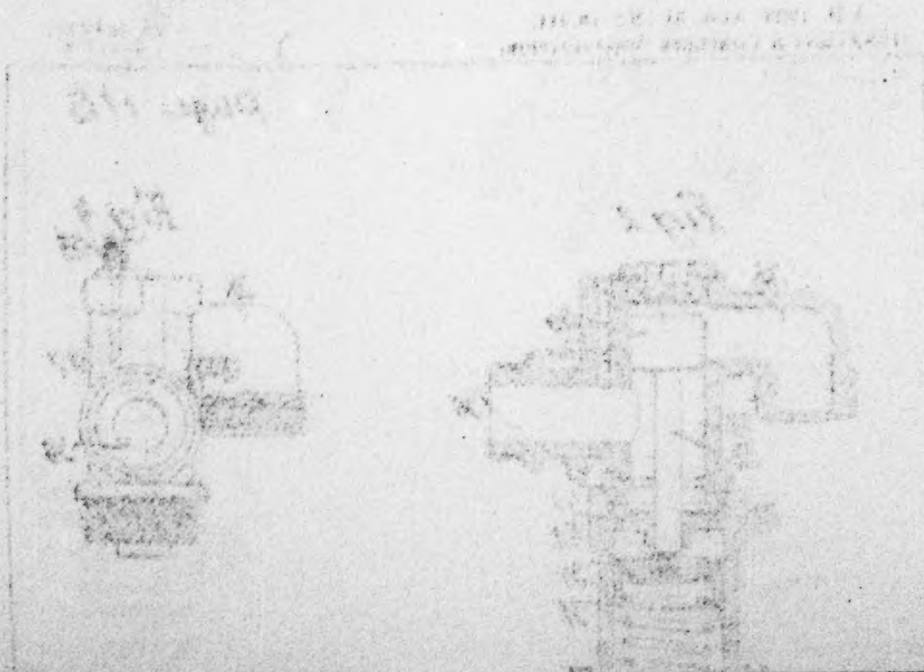

The feeding of water or the like may be rather to the combustion chamber, and means

of water into the heating chamber and this high pressure mixture reduced down to working pressure.

It has also been heretofore proposed to arrange automatic pressure retarding apparatus between the compressed air reservoir and the motor, the characteristic feature of such apparatus being that in a casing connected to the compressed air pipe there are placed two movable pistons which are connected with each other and acted upon by spring pressure and of which the larger one acts as a brake piston, while the smaller one comprises a cylindrical portion adapted to close the opening for the passage of the air and a conical portion which projects upwardly into the compressed air entrance chamber This conical portion is pressed down onto its seat by the spring and also by the compressed air, which fills the whole of the compressed air pipe when the compressed air is admitted to the apparatus, while, as soon as the pressure of the air in the pipe leading to the motor falls, owing to the starting of the motor, the piston is shifted against the action of the spring and the brake piston, by the compressed air acting upon its other side so that after its cylindrical portion has completely emerged from the passage opening the conical portion opens the way for the passage of the air to a greater or less extent according to its position.

Now the object of this invention is to provide an improved or more perfect construction of apparatus of this type.

In a complete torpedo plant embodying the improved apparatus the working is as follows:

1. The pressure in the compressed air heating apparatus is reduced to such an extent at the commencement, after starting the motor, that the rise of pressure effected by the first ignition of the charging mixture is never such as to exert any injurious effect on the motor.

2. The pressure after ignition has been effected is gradually raised so that the motor is gradually started in a way that obviates injuriously effecting it.

3. The relative times of the commencement of the supply of fuel and water, as well as of the actuation of the igniting device are so regulated that they follow each other in such order as to ensure satisfactory working.

4. Finally, should the torpedo accidentally turn over during the [fol. 116½] preliminary manipulation therewith, the improved apparatus prevents the fuel or the water from running out of the corresponding reservoirs into the pipe or into the heating apparatus and so into the engine.

All these conditions in working can be attained in a simple way by a pressure retarding device constructed as regards its essential features substantially as the one before indicated, as heretofore proposed, but the improved apparatus constructed according to this invention is also adapted to at the same time suitably control the supply of air, fuel and water.

Fig. 1 of the accompanying illustrative drawings is a general representation of a compressed air motor plant for a torpedo.

Figs. 2, 3, 4 and 5 show the pressure retarding and controlling apparatus in vertical longitudinal section, plan, part side elevation and vertical section corresponding to the line x—x of Fig. 3, respectively.

1 is the compressed air reservoir from which a pipe 2 leads to the starting valve 3 that is connected by a pipe 4 to the pressure regulator 5.

A pipe 6 places the pressure regulator 5 in communication with the pressure retarding and controlling apparatus 7, from which the compressed air passes through a union 8 into the heating apparatus 9.

The heating apparatus 9 and the fuel supplying and igniting apparatus may be constructed as described in the Specification of Letters Patent No. 7390 of 1906, that is to say it comprises a casing mounted upon the fuel reservoir 10 and in which a vessel 11 surrounding the combustion chamber and open at the top is so placed that an annular space 12 is left all round it between it and the wall of the chamber. This vessel 11, which, for the purpose of intimately mixing the fuel with the compressed air may be provided with a perforated partition, tapers at the bottom into a cylindrical portion 14 of reduced diameter surrounded by an enlarged annular space 13 and mounted upon the fuel reservoir 10, and projecting upwardly into this portion 14 is an ascension pipe 15 that depends nearly to the bottom of the fuel reservoir 10 and the upper end of which carries a cylindrical head 16 formed with radial holes 17. The head 16 extends nearly to the wall of the surrounding portion 14 and in a way divides the vessel 11 into two parts connected by the narrow annular space around the head 16. The lower part of the vessel 11 communicates by holes 18 with the annular space 13 into which the union 8 opens. Upon the outside of the casing of the heating apparatus is an annular passage 19 which communicates by a pipe 21 with the water reservoir 20 and by small holes in the casing with the annular space 12 surrounding the vessel 11.

22 is the ignition device to be set in operation by the compressed air and which by means of the pipe 23 communicates with a pressure retarding apparatus and controlling device 7 constructed according to this invention. This apparatus 7 also communicates by means of a pipe 24 with the water reservoir 20 and by means of a pipe 25 with the fuel reservoir.

26 is a pipe leading to the motor.

If the fuel reservoir 10 be charged with fuel and the starting valve 3 be opened compressed air will flow through the pipes 2 and 4 through the pressure regulator 5 and through the pressure retarding device and controlling apparatus 7 (to be hereinafter described) into the heating apparatus where it fills the chambers thereof. It passes also through the pipe 25 into the fuel reservoir 10 and drives fuel through the ascension pipe 15 and upwardly through the radial perforations 17 in the body 16 where it mixes with the compressed air and is ignited by the ignition apparatus 22 which is likewise set in action by the compressed air through the pipe 23. Water is simul-

taneously forced out of the reservoir 20 through the pipe 21 into the annular passage 19, thence through the holes in the casing of the heating apparatus into the annular passage 12, where it is broken up into a fine state of subdivision by the compressed air flowing through, and mixed therewith. In the upper part of the heating apparatus this mixture meets with the outgoing hot gases of combus- [fol. 117] tion with which it mixes, the atomised water being simultaneously converted into steam, and the mixture which finally results is supplied to the motor for the performance of work.

In order to regulate the method of working herein described, particularly when starting the motor, the improved pressure retarding apparatus and controlling device 7, shown to a larger scale in Figs. 2, 3, 4 and 5 is constructed as follows:

The apparatus comprises two superposed cylindrical casings 27 and 28, which are separated from each other by a partition 29 formed with a central hole. In each of the two casings 27 and 28 is inserted a somewhat tightly fitting piston 30 and 31 respectively, which are connected to each other, either rigidly or flexibly, by a piston rod 32 which passes through the central hole in the partition 29. Underneath the lower piston 31 is placed a powerful helical spring 33 by the force of which both pistons are constantly forced upwardly. The space below the piston 31 is also filled with a fluid that retards downward movement of such piston which is formed with a small passage 34 through which the fluid is forced on the downward movement of the piston.

The upper casing 27 is provided with two large branches 35 and 36 and three small branches 37, 38 and 39 which open into the interior of the casing. The branch 35 serves for the admission of air and is therefore connected to the pipe 6, see Fig 1. The branch 36 which is at a slightly lower level serves for the outlet of air to the heating apparatus and is therefore connected to the pipe 8, see Fig. 1. Between these two branches 35 and 36 are placed at definite heights the three smaller branches 37, 38 and 39 which serve for the pipe connections to the fuel reservoir, the water reservoir and the ignition device respectively.

These three branches are so arranged that the openings therefrom leading into the casing 27 are completely shut off by the upper piston 30 when this piston is in its highest position, in which position however a small space remains between it and the upper end of the casing 27 and from this space above the piston a narrow passage 40 formed through the wall of the casing leads to the lower branch 36, so that even when the piston is in this position a portion of the compressed air can pass over from the branch 35 to the union 36.

When the apparatus is not in action the piston 30 effectually closes the two connecting pipes 8 and 24 to the fuel and water reservoirs so that when the torpedo is turned over during the manipulation therewith neither fuel nor water can pass through these pipes to the heating apparatus.

The length of the casing 27 is such that beneath the lower branch 36 there is sufficient room for the upper piston 30 when in its lower position to completely uncover the mouth of the branch 36. T

lower part of the casing 27 is formed with two annular grooves 41 and 42 which are in communication with each other as by a longitudinal groove and the upper one of which communicates with the branch 36 by a longitudinal groove 43. The purpose of these grooves is to allow compressed air which gradually gets under the piston 30 owing to its not being perfectly tight to escape again and to ensure that the air underneath the piston 30 shall always be at the same pressure as that emerging from the branch 36 whereby a difference of pressure is produced which keeps the piston in its lowest position during the whole run of the torpedo.

On opening the starting valve 3 the compressed air passes as heretofore stated through the regulator 5 to the retarding device 7 and at first, owing to the position of the piston 30, only a small part of the compressed air will pass, through the passage 40 and branch 36 into the pipe 8 and into the heating apparatus. By the continued pressure of the air however the two pistons 30 and 31 of the retarding apparatus are slowly forced downwardly, the lower piston acting as a brake piston. During this movement the three small branches 37, 38 and 39 are gradually opened so that the compressed air passes into the fuel reservoir 10 through the branch 37 and the [fol. 118] pipe 25 whereby the supply of the fuel commences. A moment later the compressed air also passes to the ignition apparatus through the branch 39 and the pipe 23 thereby setting the ignition apparatus in action. In this way the ignition of the fuel, which has already passed into the heating apparatus, is effected at a relatively low pressure. Immediately afterwards the compressed air also passes through the branch 38 and the pipe 24 into the water reservoir 20 whereupon the supply of water to the heating apparatus also commences. Finally the piston 30 which still keeps on moving downwardly, gradually and completely uncovers the outlet 36 to the heating aparatus, the pressure in the heating apparatus gradually rising until the piston 30 reaches its lowest position. The piston 30 is then kept in this lowest position owing to there always being, in consequence of the longitudinal groove 43 and annular grooves 41 and 42, a somewhat lower pressure below it than there is above it so that the tension of the spring is overcome.

When the torpedo has concluded its run the starting valve 3 is closed automatically after which the pistons 30 and 31 are returned to their uppermost position by the pressure of the spring 33.

The constructional formation of the improved pressure retarding apparatus and controlling device obviously permits of numerous modifications while ensuring the above described method of working and without departure from this invention. Thus for example instead of the upper piston 30 another suitable controlling device, say a slide valve, could be employed operated by a piston which is subject to the pressure of the compressed air for the purpose of obtaining the desired automatic movement.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed I declare that what I claim is:

N° 393.324

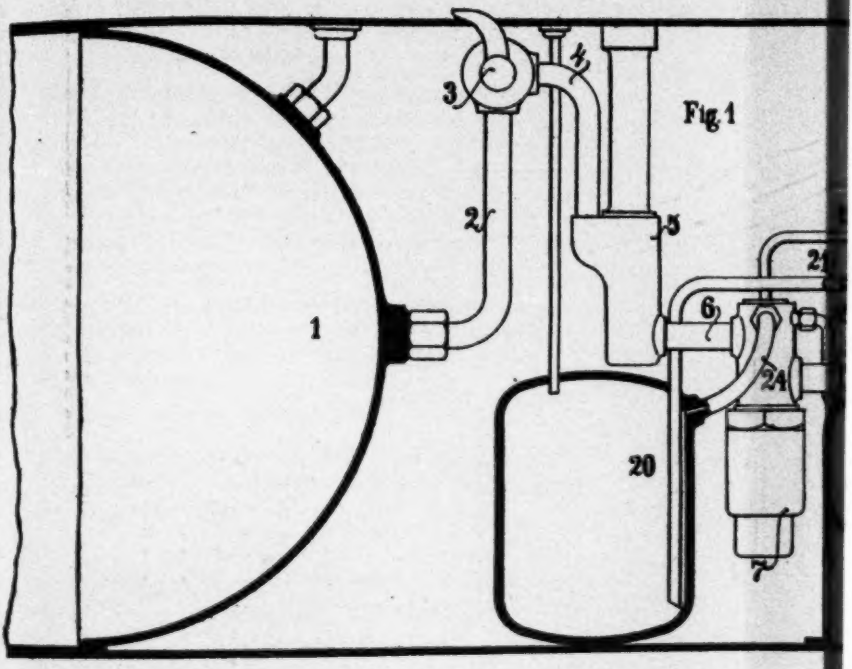

Fig. 1

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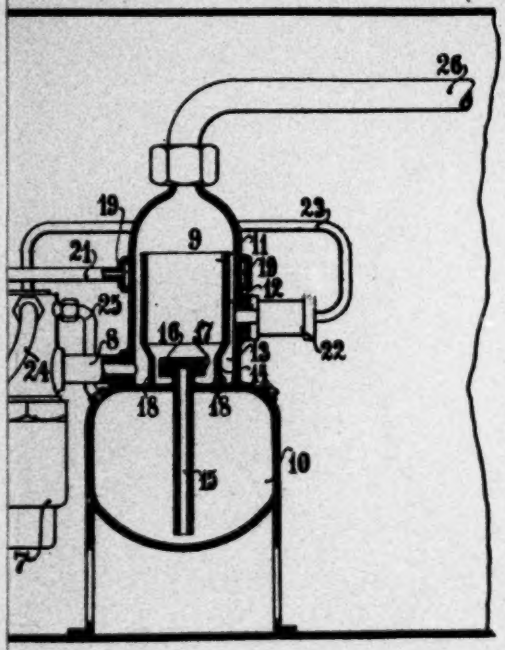

Fig. 2

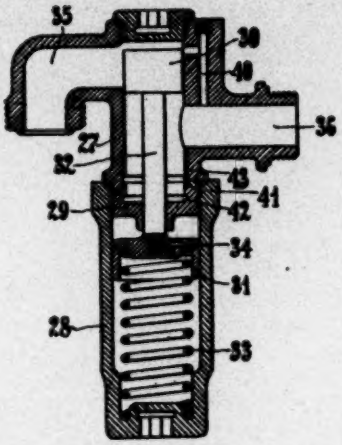

Fig. 4

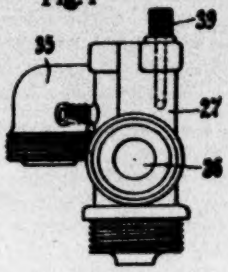

Fig. 5

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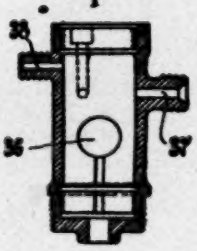
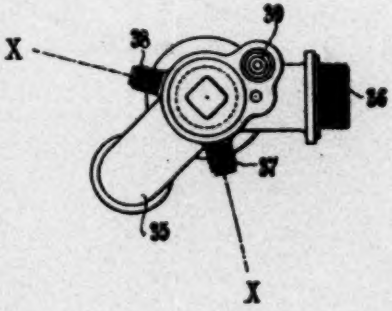
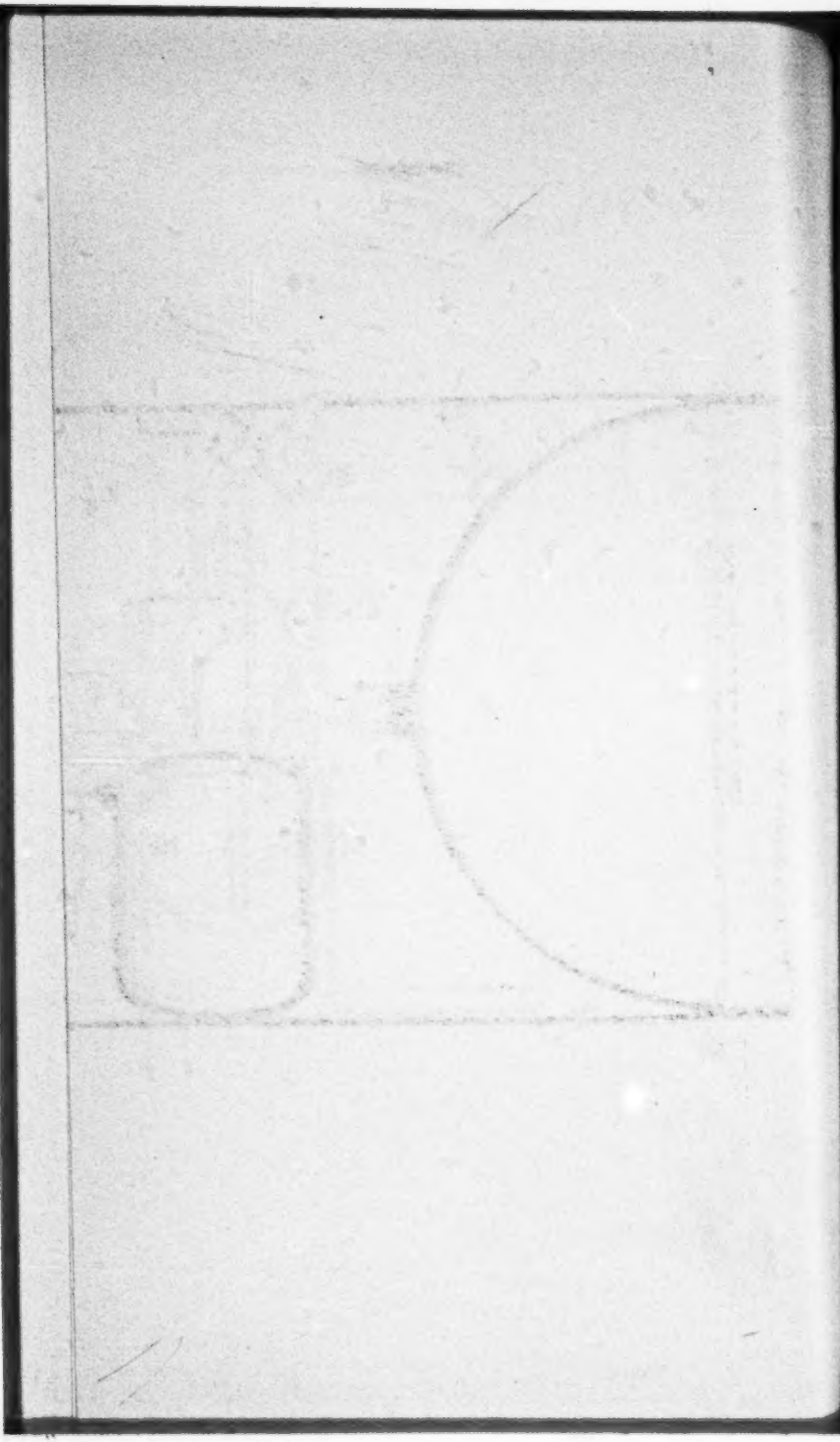


Fig. 3





1. Pressure retarding apparatus, for compressed air motor plants, of the kind wherein a piston valve, which is provided with a brake piston and acted upon by spring pressure or other controlling device acted upon by a piston, wholly or partially cuts off, when in its normal position, the outlet opening to the motor or to the compressed air heating apparatus, and, when it is displaced by the entering compressed air, gradually uncovers the outlet opening, characterised by the fact that the pipe connections with the fuel reservoir, the water reservoir, and the ignition device which is worked by compressed air, open into the piston valve casing in such way that when the piston valve or controlling device is in its normal position these connections are obstructed or shut off and are only gradually opened as the piston valve is moved by compressed air, so that the motor is started gently and without noise.

2. Pressure retarding apparatus according to Claim 1, in which the underside of the piston valve or the piston acting upon the controlling device, constantly communicates with the compressed air outlet opening for the purpose of keeping up a constant difference of pressure on the two sides of the piston valve in order to overcome the spring pressure and by this means to keep the piston in its lowest position during the entire run of a compressed air driven torpedo fitted with the apparatus.

3. Pressure retarding apparatus for compressed air motor plants of the kind referred to, constructed, arranged and operating substantially as hereinbefore described with reference to and shown in the accompanying drawings.

Dated this 31st day of August 1908.

For the Applicant, Lloyd Wise & Co., 46 Lincoln's Inn Fields, London, W. C., Chartered Patent Agents. (Seal of the Court of Claims.)

(Here follow side folio pages 119 and 120.)

[fol. 121]

République Française

Office National De La Propriété Industrielle

Brevet D'Invention

No. 393.324

VI.—Marine et navigation.

1.—Construction des navires et Engins de Guerre.

Dispositif de retardement de pression automatique pour surchauffeur d'air pour torpilles.

M. Johann Gesztesy résidant en Hongrie.

Demandé le 20 juillet 1908

Délivré le 22 octobre 1908.—Publié le 19 décembre 1908

Dans le brevet français n° 373.757, du 27 mrs 1906, on a décrit un procédé et un dispositif pour augmenter le travail fourni par les moteurs à air comprimé, en particulier pour les torpilles automobiles, dans lesquels on mélange l'air comprimé, tout en maintenant sa tension, avec un combustible liquide finement divisé, celui-ci étant enflammé dans une chambre de chauffe spéciale, dans la quelle se produit une combustion continue pendent la marche du moteur, par suite de la chute de pression provoquée par cette marche. En même temps la quantité de matiére combustible offerte effectivement à la combustion est exactement délimitée par l'introduction d'une quantité déterminée de combustible soumis à la pression originelle de l'air comprimé; les gaz de la combustion sont ensuite mélangés avec de la vapeur d'eau, obtenue par l'introduction d'eau dans la chambre de chauffe et ce mélange à haute tension est réduit à la pression de fonctionnement.

En outre on a proposé un appareil de retardement de pression automatique, qui est intercalé entre le réservoir d'air comprimé et le moteur et est caractérisé par le fait que, dans une boîte intercalée sur la conduite d'air comprimé, sont disposés de façon mobile deux pistons réunis ensemble et soumis à une action de ressort, dont le plus grand agit comme piston-frein, tandis que le plus petit se compose d'une partie cylindrique obturant l'ouverture de passage de l'air et d'une partie rétrécie coniquement, située au-dessus de la précédente et pénétrant dans la chambre d'arrivée de l'air comprimé; cette dernière partie est pressée sur son siège, tant par le ressort que par l'air sous pression que remplit toute la conduite d'air comprimé lors du remplissage de la chaudière, mais, dès que la pression de l'air dans la conduite allant au moteur tombe par suite de la mise en marche de ce dernier, elle est déplacée par l'air comprimé agissant sur son autre face malgré l'action du ressort et du piston-frein, de telle sorte qu'elle donne libre passage à l'air suivant sa forme conique, après que sa partie cylindrique s'est complètement retirée de l'ouverture de passage.

L'invention ci-dessous décrite a pour objet une amélioration c'est-à-dire un perfectionnement des dispositifs en question, les dispositions perfectionnées garantissant alors dans son intégralité le mode de fonctionnement suivant:

1° La pression dans l'appareil de chauffe est, immédiatement après le départ du moteur, suffisamment diminuée pour que l'augmenta-

[fol. 122] tion de pression résultant du premier allumage du mélange de charge ne puisse avoir aucune conséquence nuisible pour le moteur;

2° Par l'augmentation graduelle de pression après l'allumage effectué, le moteur est mis peu à peu en action, ce qui met également le moteur à l'abri d'influences perturbatrices;

3° Les instants où commencent l'alimentation en eau et en combustible, et la mise en train du dispositif d'allumage sont réglés de manière à se succéder pour le fonctionnement le plus favorable;

4° Enfin le nouveau dispositif évite que, si la torpille se renverse accidentellement pendant qu'on la manipule, le combustible ou l'eau ne s'écoule hors des réservoirs appropriés dans la conduite c'est-à-dire dans l'appareil de chauffe et dans le machine.

Tout cela peut être obtenu de manière simple grâce à un dispositif de retardement de pression qui est en substance disposé comme celui susmentionné, mais avec cette différence qu'il renferme en même temps un mécainisme de distribution qui contrôle de manière convenable l'alimentation d'air, de combustible et d'eau.

Dans les dessins, la fig. 1 représente l'ensemble de l'installation pour une torpille, tandis que les fig. 2, 3, 4 et 5 font voir les organes de retardement de pression et de distribution, respectivement en coupe longitudinale, en plan, en élévation latérale et en coupe suivant x-x (fig. 3).

Du réservoir d'air comprimé 1, part un tuyau 2 vers la valve de mise en route 3, de laquelle un tuyau 4 mène au régulateur de pression 5. Celui-ci communique par le tube 6 avec l'appareil 7 de retardement de pression et de distribution hors duquel l'air comprimé s'échappe à travers la tubulure 8 dans l'appareil de chauffe 9. Ce dernier, ainsi d'ailleurs que les dispositifs d'alimentation de combustible et d'allumage, peuvent être construits comme représenté dans le mémoire descriptif joint au brevet n° 373.757 susmentionné. L'appareil de chauffe se compose également d'une enveloppe placée sur le réservoir à combustible 10, et dans laquelle un vase 11 ouvert en haute et entourant la chambre de combustion est établi de manière à laisser autour de lui un espace annulaire libre 12. Ce vase 11, qui peut être pourvu d'un diaphragme pour le mélange intime du combustible avec l'air comprimé, se rétrécit vers le bas suivant une espèce de tubulure cylindrique 14 reposant sur le réservoir à combustible 10 et entourée de l'espace annulaire élargi 13; dans cette tubulure pénètre vers le haut un tube élévateur 15 qui descend jusqu'auprès du fond du réservoir 10 et qui porte, à son orifice supérieur, un corps cylindrique 16 avec perforations radiales 17. Ce cylindre divise ainsi l'espace de l'appareil de chauffe à l'intérieur de la tubulure, 14 en deux compartiments communiquant par un rétrécissement annulaire. Le compartiment inférieur communique par les trous 18 aver l'espace annulaire 13 dans lequel débouche la tubulure 8. Sur la paroi latérale extérieure de l'enveloppe de l'appareil de chauffe est disposé un canal annulaire 19 qui communique d'une part avec le tuyau 21 conduisant au réservoir d'eau 20 et d'autre

part, grâce à des petits trous de l'enveloppe, avec l'espace annulaire 12 entourant le vase 11.22 este le dispositif d'allumage qui doit être mis en activité par l'air comprimé et qui communique par le tuyau 23 aver le dispositif 7 de retardement de pression et de distribution. Ce dispositif 7 communique en outre par le tuyau 24 avec le réservoir d'eau 20 et par le tuyau 25 avec le réservoir de combustible 10. Le conduit 26 mène au moteur.

Le réservoir 10 étant rempli de combustible et la valve de mise en route 3 étant ouverte, l'air sous pression arrive par les tuyaux 2 et 4, le régulateur de pression 5 et le dispositif de retardement de pression et de distribution ci-dessous décrit, à l'appareil de chauffe dont il remplit la capacité. Par le tube 25 il pénètre également dans le réservoir à combustible et chasse le combustible, à travers le tube élévateur 15 et les perforations radiales 17, vers la partie supérieure où ce combustible se mélange à l'air comprimé et est enflammé par le dispositif d'allumage mis simultanément en activité par l'air comprimé arrivant par le tube 23. En même temps, de l'eau est refoulée du réservoir 20 par le tuyau 21 dans le canal annulaire 19; cette eau passe par les trous de l'enveloppe de l'appareil de chauffe dans l'espace annulaire 12 où elle est finement pulvérisée par l'air sous pression qui s'y précipite, et se mélange à cet air. Ce mélange se [fol. 123] brasse dans la partie supérieure de l'appareil de chauffe avec les gaz de combustion chauds qui s'échappent, en même temps que l'eau pulvérisée se transforme en vapeur, le mélange finalement obtenu étant conduit au moteur pour utilisation de son énergie.

Pour pouvoir maintenant, c'est-à-dire lors du départ du moteur, régler convenablement le fonctionnement indiqué, l'appareil de retardement de pression et de distribution représenté à plus grande échelle par les fig. 2, 3, 4 et 5 est conformé comme suit.

Il se compose de deux chambres cylindriques 27 et 28 superposées séparées l'une de l'autre par une cloison intermédiaire 29. Dans chaque chambre se trouve un piston étanche, respectivement 30 et 31, ces deux pistons étant reliés ensemble rigidement ou de manière articulée par une tige 29 pouvant aller et venir dans une lumière ou un passage de la cloison intermédiaire 29. En dessous du piston inférieur 31 est disposé un fort ressort à boudin 33 qui tend à soulever constamment les deux pistons vers le haut. L'espace en dessous du piston 31 est en outre rempli d'un liquide de freinage. Le piston 31 est percé d'un étroit canal 34 à travers lequel le liquide de freinage est forcé, lorsque le piston est déplacé dans sa direction.

Dans la chambre supérieure 27 débouchent deux grosses et trois petites tubulures. La tubulure 35 sert pour l'arrivée d'air et est en conséquence reliée au tuyau 6 (fig. 1). La tubulure 36 située un peu plus bas sert à la sortie de l'air vers l'appareil de chauffe et est donc reliée au tuyau 8 (fig. 1). Entre ces deux tubulures 35 et 36 sont situées, à des niveaux déterminés, les trois plus petites 37, 38 et 39 qui servent respectivement aux connexions avec les réservoirs de combustible, d'eau et le dispositif d'allumage. Ces trois tubulures sont disposées de telle sorte que leurs orifices débouchant dans la chambre soient complétement fermés par le piston supérieur 30

lorsque celui-ci se trouve dans sa position la plus haute, position dans laquelle il laisse cependant un petit espace libre entre lui-même et le couvercle de la boîte 27. De cet espace libre restant au-dessus du piston 30, part un canal étroit 40, pratiqué dans la paroi de la chambre et se rendant à la tubulure 36 située plus bas, de manière que, dans la position susindiquée, une partie de l'air comprimé puisse déjà, passer de la tubulure 35 à la tubulure 36.

Tant que l'appareil est au repos, le piston 30 obture hermétiquement les deux conduits allant aux réservoirs de combustible es d'eau, de telle sorte que, si pendant sa manipulation la torpille se renverse, ni le combustible, ni l'eau ne peuvent parvenir par ces conduits dans l'appareil de chauffe.

En dessous de la tubulure inférieure 36, on a encore ménagé dans la chambre 27 assez de place pour que le piston supérieur 30, lorsqu'il est dans sa position la plus basse, laisse complètement découvert l'orifice de la tubulure 36. Au bas de la chambre 27 sont pratiquées deux rainures circulaires 41 et 42 dont la supérieure communique avec la tubulure 36 par une saignée longitudinale 43. Ceci a pour but de laisser de nouveau échapper l'air sous pression qui arrive progressivement sous le piston 30 par suite de la nonétanchéité de ce dernier, et de maintenir constamment l'air qui se trouvre en dessous du piston 30 à la même pression que celui qui s'échappe par la tubulure 36; grâce à cela, on assure une différence de pression qui maintient fortement le piston à sa position la plus basse pendant toute la course de la torpille.

Au moment où l'on ouvre la valve de mise en route 3, l'air comprimé se rend également à travers le régulateur de pression 5 au dispositif retardateur 7 et une petite portion seulement de cet air comprimé par le canal 40 dans le tuyau 8 et dans l'appareil de chauffe. La pression de l'air refoule lentement verse le bas les deux pistons 30 et 31 du dispositif retardateur, le piston inférieur 31 agissant comme frein. Par suite les orifices des trois petites tubulures 37, 38 et 39 s'ouvrent successivement de telle façon que l'air sous pression arrive en premier lieu, par le tuyau 25, dans le réservoir à combustible 10, ce qui fait commencer l'alimentation en combustible. Un moment apres, l'air comprimé arrive également par la conduite 23 au dispositif d'allumage 22 qu'il met en activité. Ainsi s'effectue l'allumage du combustible arrivant dans l'appareil de chauffe sous une pression relativement faible. Ensuite l'air com-
[fol. 124] primé parvient également par le tuyau 24 au réservoir d'eau 20, cequi met en route l'alimentation d'eau dans l'appareil de chauffe. Enfin, le piston se déplaçant toujours de plus en plus vers le bas découvre progressivement jusqu'à ouverture complète la sortie vers l'appareil de chauffe, ce qui fait que la pression dans cet appareil s'accroît peu à peu jusqu'à ce que le piston 30 ait atteint sa position la plus basse. Le piston est alors maintenu fortement dans cette position par le fait que la pression régnant sur sa face inférieure reste grâce aux rainures longitudinale 43 et annulaires 41 et 42, constamment plus faible que celle régnant sur sa face supérieure, de manière à vaincre la tension du ressort.

Lorsque la torpille a terminé sa course, la fermeture de la valve de mise en route s'opère automatiquement, ce qui a pour effet de faire revenir les pistons 30 et 31 à leur position la plus haute par suite de la poussée du ressort.

Les dispositions de construction de ce dispositif de retardement de pression et de distribution peut bien entendu supporter des modifications variées à condition de respecter le mode de fonctionnement indiqué ci-dessus. Par exemple le piston supérieur 30 pourrait être remplacé par un autre organe de distribution, comme un tiroir, qui serait contrôlé, pour déplacement automatique, par un piston soumis à l'action de l'air comprimé.

Résumé

L'invention porte plus particulièrement sur les points suivants:

1° Un dispositif retardateur de pression pour installations de moteurs à air comprimé dans lequel un piston-tiroir ou autre organe de distribution contrôlé par un piston réuni à un piston-frein et soumis à l'action d'un ressort, obture complètement ou partiellement dans sa position normale l'orifice de sortie vers le moteur ou vers l'appareil de chauffe de l'air comprimé, et découvre au contraire peu á peu cet orifice de sortie lorsqu'il est déplacé par l'air comprimé, caractérisé par le fait que, des tuyaux de jonction respectivement avec le réservoir de combustible, le réservoir d'eau et le dispositif d'allumage à mettre en train par l'air comprimé, débouchent dans la chambre du piston-tiroir de façon à être obturés dans la position normale du tiroir à piston ou organe de distribution, et à être ensuite découverts l'un après l'autre par le déplacement du tiroir à piston provoqué par l'air comprimé, de telle sorte que le départ du moteur s'effectue avec douceur;

2° Le mode d'exécution caractérisé par le fait que la face postérieure du tiroir à piston c'est-à-dire du piston contrôlant l'organe de distribution, reste constamment en communication avec l'orifice de sortie, dans le but de maintenir entre les deux faces du piston-tiroir une différence de pression constante qui permette de vaincre la poussée du ressort et de maintenir ainsi le piston dans sa position la plus basse pendant toute la course de la torpille.

Johann Gesztesy. Par procuration: G. Protte.

[fol. 124½] Revista Maritima Brazileira

Parafusos para a ligação da cabeça	22
Parafusos para o fluctuador	20
Parafusos para a cauda	12

O torpedo com a cabeça de combate, o reservatorio carregado a 80 atm. e a machina sem agu deverá ter a fluctuabilidade de 4 a 5 kg., n'agua de densidade 1.027 e temperatura de 17° C.

O apparelho Obry para estes torpedos será feito de modo que o

angulo de lançamento possa ser dado ou alterado pela parte externa do torpedo.

Aquecedor de ar paia torpedos, systema Gesztezy

Dos apparelhos destinados ao aquecimento do ar durante a carreira do torpedo e presentemente em experiencias na casa Whitehead, parece-nos que o aquecedor inventado pelo 1° tenente Gesztezy, da marinha austriaca, será o preferido, si as provas de lançamento tiverem o mesmo resultado que as experiencias preliminares.

Até agora a principal vantagem deste apparelho sobre o Armstrong é permittir que a machina do torpedo conserve todas as suas peças de bronze, o que não acontece com o aquecedor inglez, no qual, devido á sua temperatura, torna-se necessario o emprego do aço nos embolos e valvulas de distribuição, sendo portanto mais difficil a conservação do motor.

Não nos é possivel dizer em que consiste o funccionamento do aquecedor Armstrong, porque os dois torpedos em que este apparelho faz suas experiencias não são desmontados á vista de estranhos.

[fol. 125] Quanto, porém, ao aquecedor Gesztezy, cujas experincias preliminares não foram secretas e cujo schema pudemos obter, faremos o possivel para dar uma idéa geral do seu funccionamento.

No torpedo em que este aquecedor está montado, elle occupa o compartimento dos reguladores de immersão, usando o torpedo o novo apparelho de immersão collocado no compartimento da machina.

O fim do aquecedor Gesztezy é converter aos poucos em vapor a agua contida num reservatorio, sequindo este com o ar a desempenhar na machina o papel de ar aquecido.

O apparelho completo compõe-se do seguinte:

Apparelho aquecedor propriamente dito E.

Apparelho retardador I.

Deposito de combustivel (benzina) F.

Deposito d'agua G.

Pistola H.

O apparelho aquecedor é constituido pela campanula externa T, tendo no interior o vaso cylindrico t que limita o espaco para a combustão, ficando entre elle e a campanula externa o espaco circular d.

O vaso interno t diminue de diametro na parte inferior f, formando-se o espaco circular maior e; na parte inferior de t sahe o tubo a que termina na parte superior por um corpo cylindrico g, onde existem os furos alongados h.

Por meio deste corpo, a parte de menor diametro de t fica dividida em duas partes, apenas em communicação por meio dum pequeno espaço circular, ficando ainda a parte inferior em communicação com o espaço e por meio dos furos i.

[fol. 126] Na campanula T existe o canal circular l em communicação com o tubo conductor d'agua m, e por meio dos furos n, com o espaço *t*.

Ao apparelho aquecedor é fixa a pistola H, onde um pequeno car-

tucho é detonado por percussão pela pressão do ar, trazido á pistola pelo tubo r.

Os depositos de combustivel e agua F e G são simples vasos onde existem dous tubos, um para sahida do liquido, outro para entrada do ar.

O regulador de pressão D é o mesmo usado nos torpedos.

O funccionamento do apparelho é o seguinte:

O ar vindo do reservatorio, ao encontrar abertas as valvulas de conservação e admissão, segue pelo tubo k para o regulador de pressão, donde, depois de reduzido á pressão conveniente, segue para o apparelho retardador I; dahi os tubos de pequeno diametro p, o, r conduzem ar aos depositos d'agua, de combustivel e á pistola.

Terminado o trabalho no apparelho retardador, o ar segue para o aquccedor pelo tubo k" que termina no espaço circular e; ahi o ar se divide em duas partes, uma pequena parte penetra palos furos i, arrastando a benzina que sahe aos poucos pelos furos h, para o meio do vaso *t*, onde a mistura se inflamma; a outra parte do ar segue pelo espaço d para a parte superior do apparelho, arrastando e dispersando a agua, que sahe aos poucos pelos furos n.

Na parte superior do apparelho dá-se então a união dos productos da combustão com o ar impregnado d'agua, sendo esta instantaneamente convertida em vapor e seguindo com o ar para a machina, pelo tubo M.

[fol. 127] O apparelho retardador, cuja vista interna o schema não mostra, é a parte principal do apparelho, constituindo, segundo ouvimos, uma patente separada.

O fim deste apparelho é só permittir uma pressão minima nos primeiros momentos da carreira do torpedo, augmentando-a gradativamente até a normal.

O apparelho do tenente Gesztezy apresenta ainda as seguintes vantagens:

1.ª O primeiro accendimento da mistura dá-se com muito pequena pressão, de modo que o augmento repentino de pressão, devido ao accendimento, não póde ter nenhuma consequencia desvantajosa para o motor.

2.ª Nos lançamentos o apparelho só permitte que a machina trabalhe a toda força depois de ter o torpedo entrado n'agua, tornado-se portanto desnecessario o retardador usado actualmente.

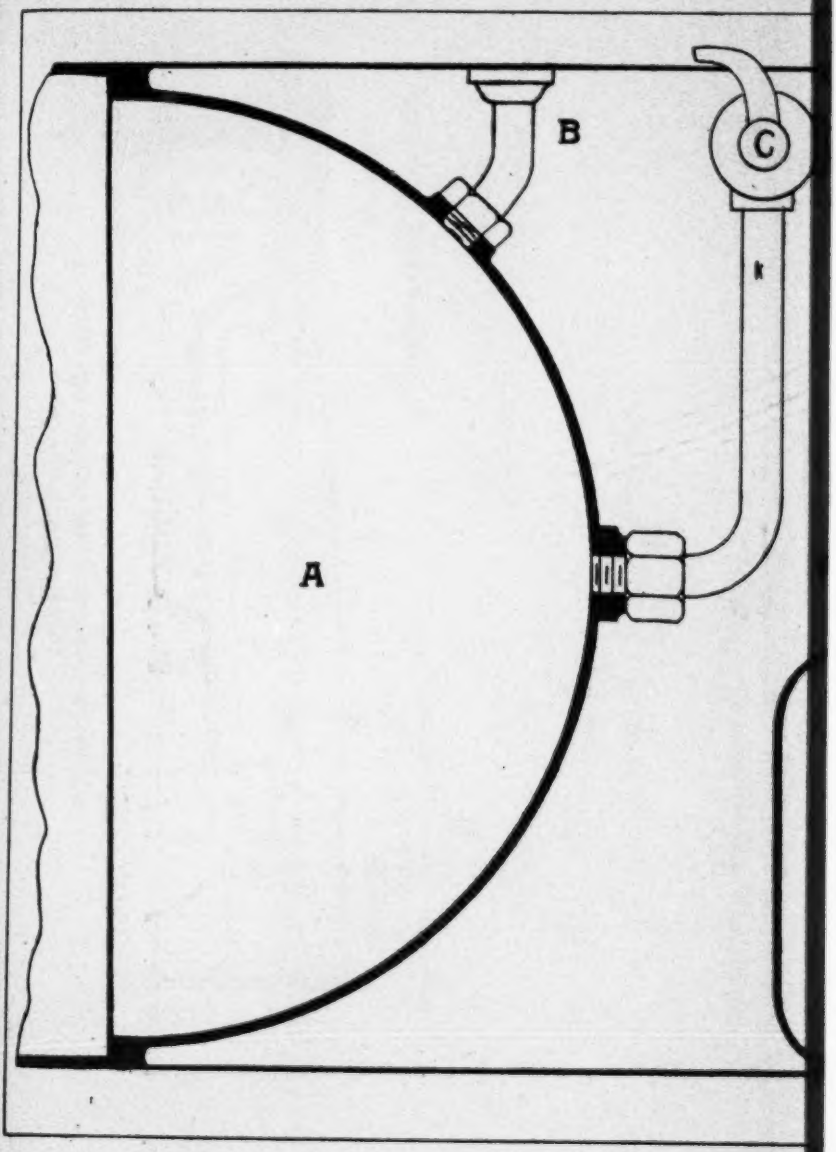
3.ª Mediante uma conforme disposição dos tubos de conducção de ar, póde-se regular exactamente o momento de introducção da benzina e da agua, como tambem o instante do accendimento.

O apparelho como está actualmente pesa, com os depositos cheios, 25 kg., tendo o deposito d'agua a capacidade de 8^{l}, 5 e o de benzina a de 1^{l}, 1.

Fiume—Novembro de 1907.

L. Neves, 2° Tenente.

(Here follows side folio page 128.)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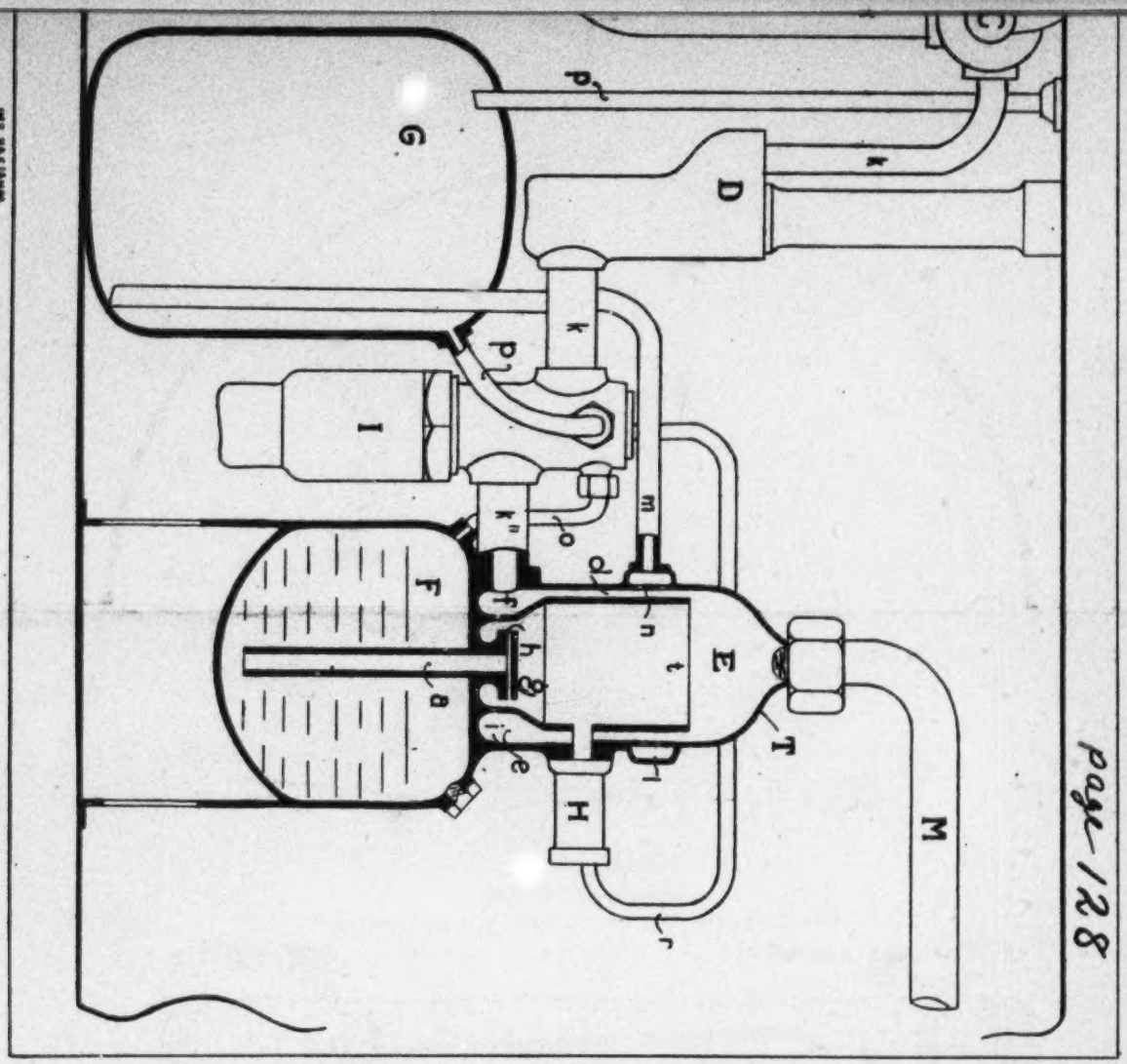

WITNESSES:
L. H. Barlow
L. B. Penfield

INVENTOR:
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ATTORNEYS

Fig. 6-15
To Court's findings

Pages 135-136

G. C. DAVISON.

AUTOMOBILE TORPEDO.

APPLICATION FILED MAR. 10, 1906. RENEWED JULY 2, 1912.

1,036,082. Patented Aug. 20, 1912.

5 SHEETS—SHEET 1.

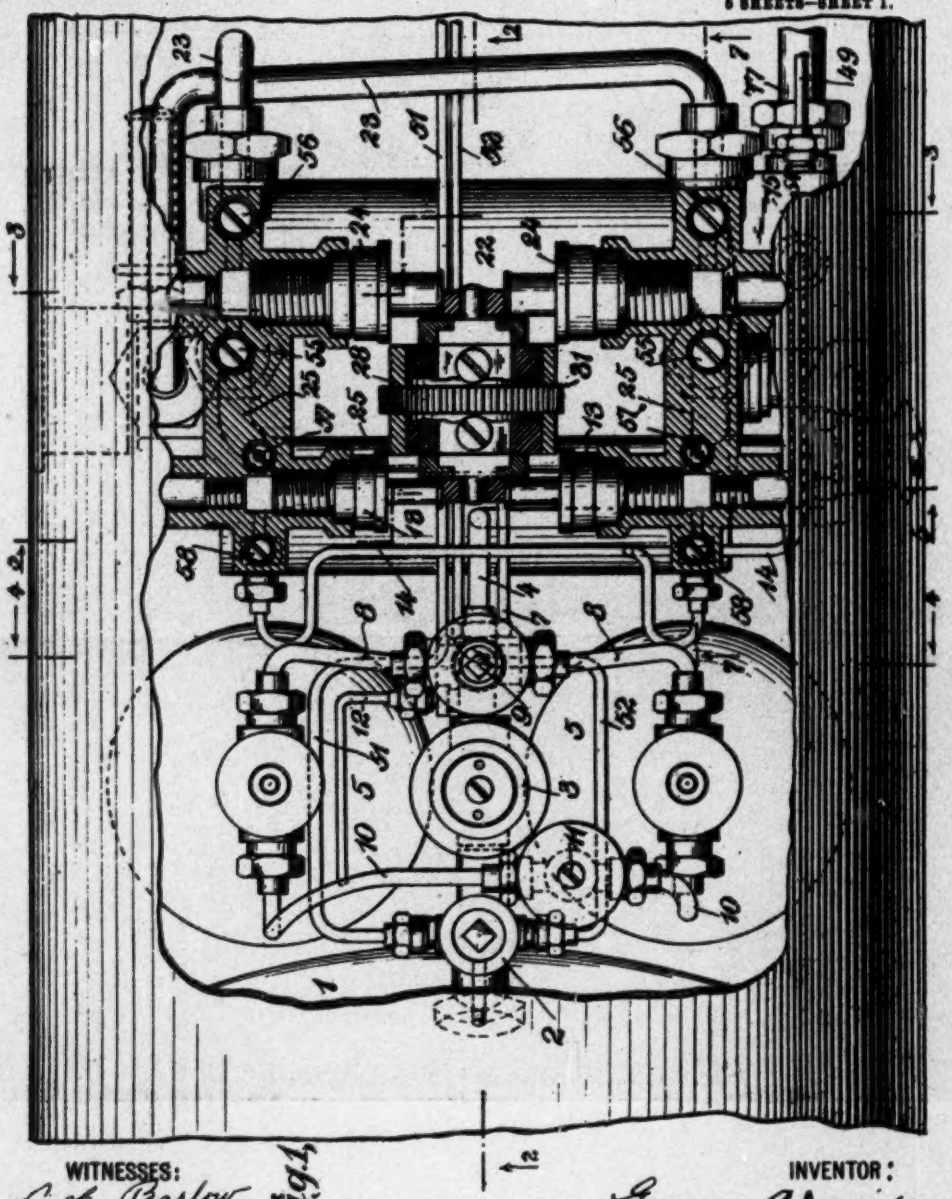

Fig. 1.

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C—15

To Court's findings

Pages 135-136

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5 SHEETS—SHEET 2.

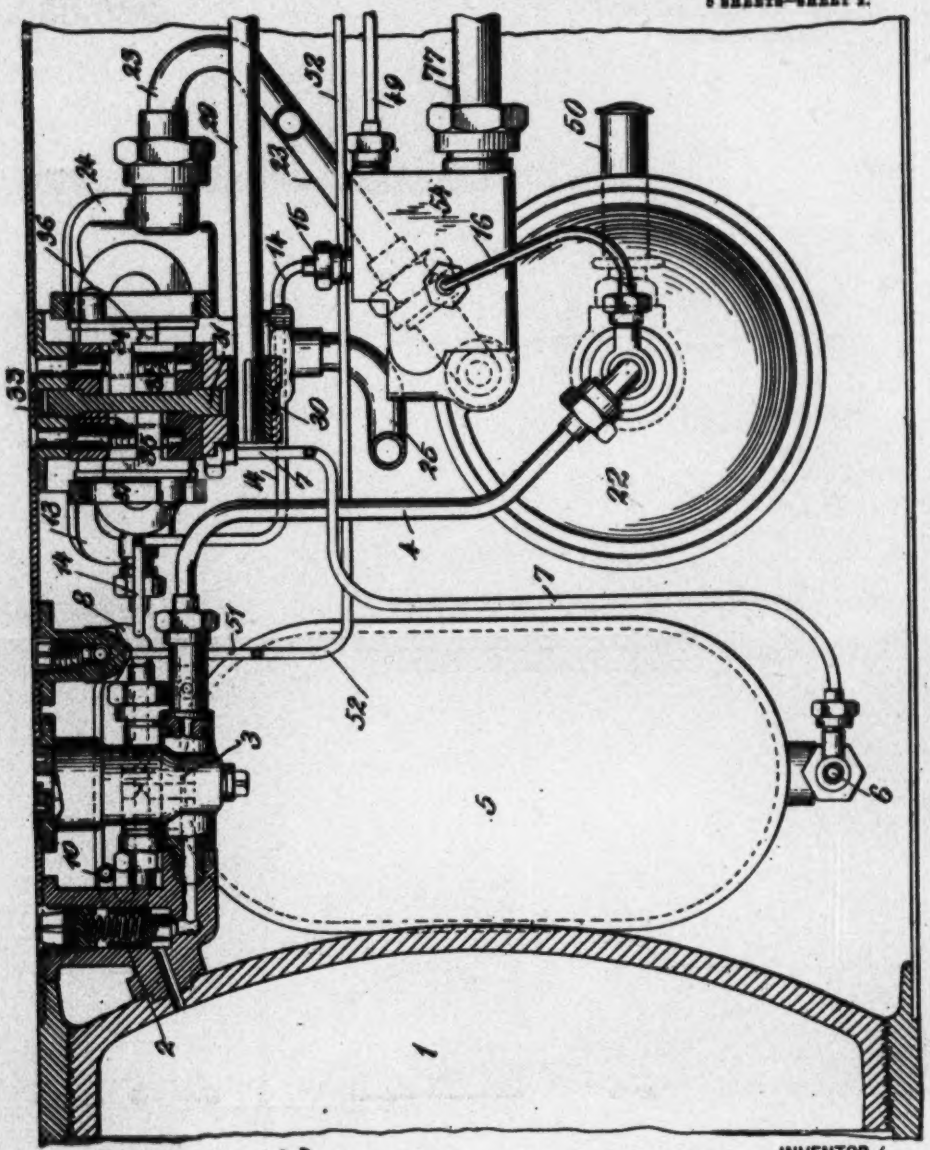

Fig. 2.

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AUTOMOBILE TORPEDO.

APPLICATION FILED MAR. 19, 1906. RENEWED JULY 8, 1912.

1,036,082.

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5 SHEETS—SHEET 3.

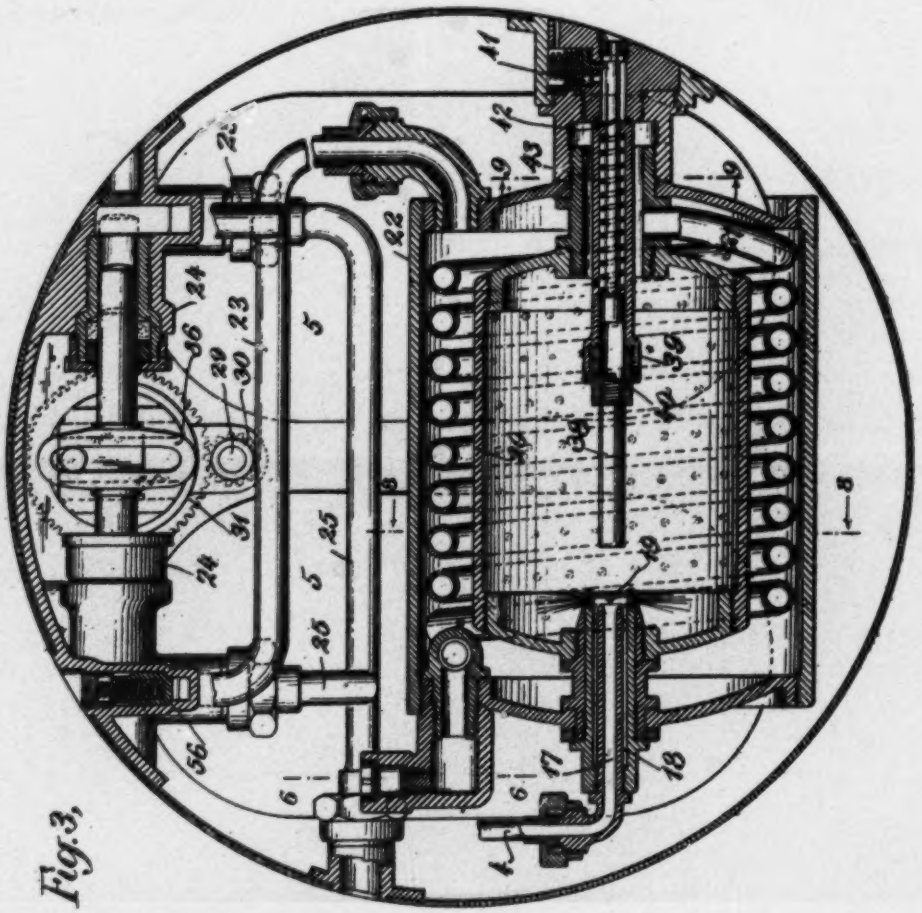

Fig. 3.

WITNESSES:

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5 SHEETS—SHEET 4.

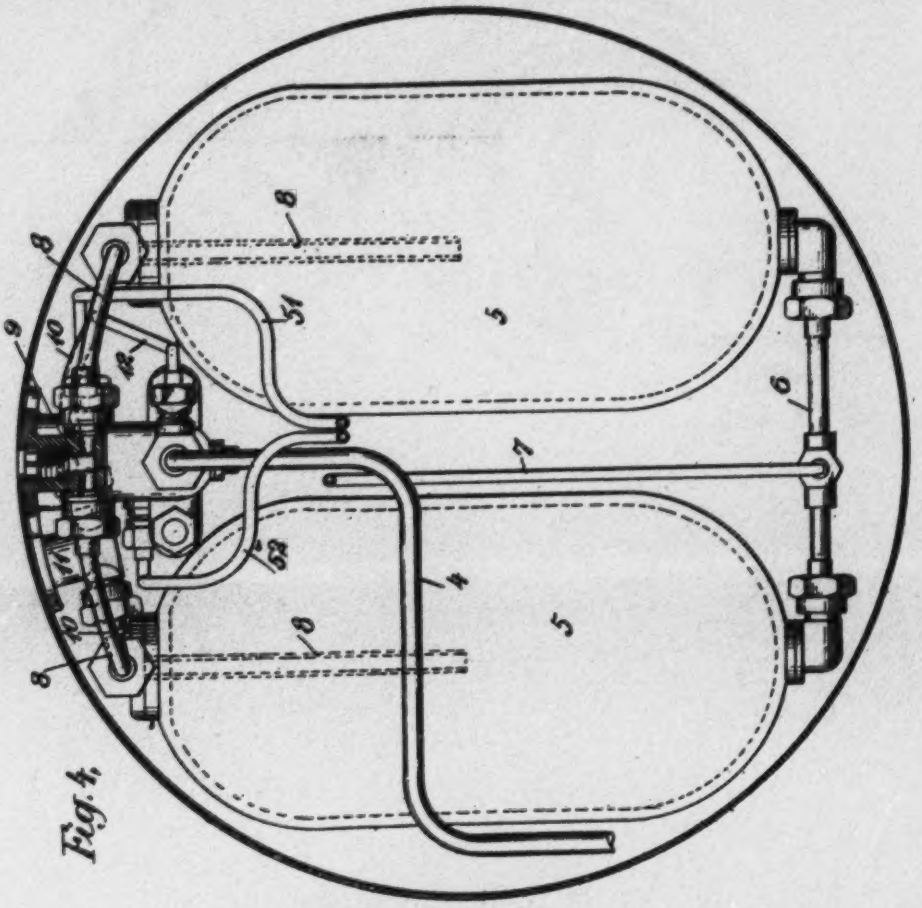

Fig. 4.

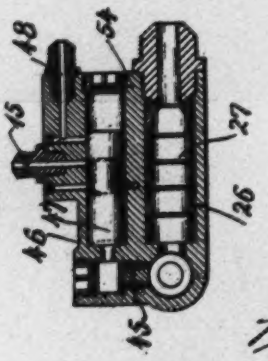

Fig. 6.

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AUTOMOBILE TORPEDO.

APPLICATION FILED MAR. 10, 1906. RENEWED JULY 3, 1912.

1,036,082.

Patented Aug. 20, 1912.

3 SHEETS—SHEET 3.

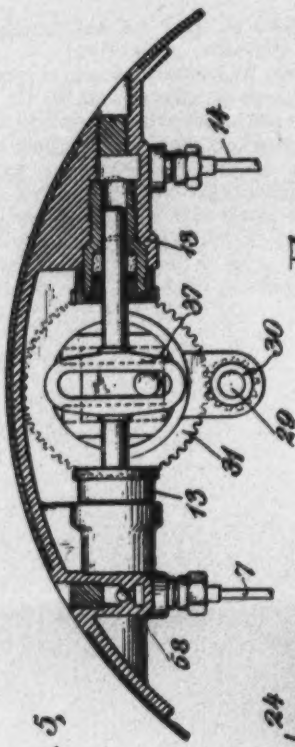

Fig. 5.

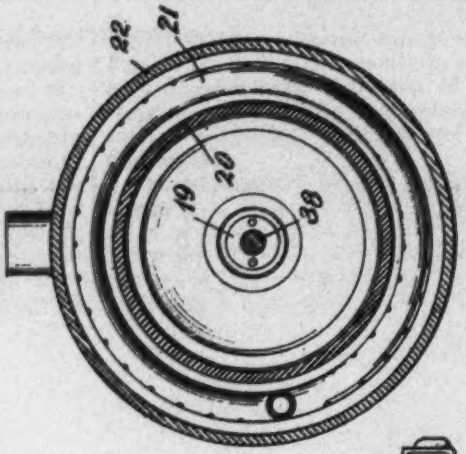

Fig. 8.

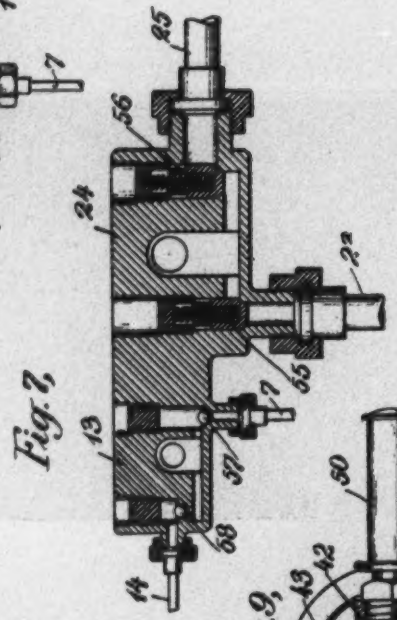

Fig. 7.

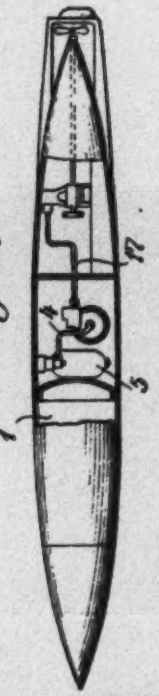

Fig. 10.

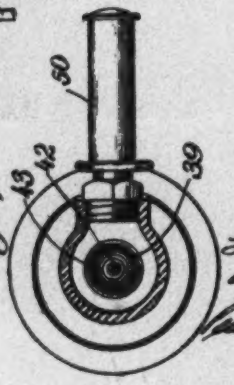

Fig. 9.

WITNESSES:

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INVENTOR:

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by Pennie Fiddebrook

ATTORNEYS.

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UNITED STATES PATENT OFFICE.

GREGORY CALDWELL DAVISON, OF QUINCY, MASSACHUSETTS, ASSIGNOR TO ELECTRIC BOAT COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

AUTOMOBILE TORPEDO.

1,036,082. Specification of Letters Patent. Patented Aug. 20, 1912.

Application filed March 19, 1906, Serial No. 422,175. Renewed July 3, 1912. Serial No. 707,606.

To all whom it may concern:

Be it known that I, GREGORY CALDWELL DAVISON, a citizen of the United States, residing at Quincy, in the county of Norfolk and State of Massachusetts, have invented certain new and useful Improvements in Automobile Torpedoes; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

It has been common practice to propel automobile (or self-propelled) torpedoes by compressed air, which is fed from a storage reservoir to a suitable motor attached to the propeller shaft of the torpedo. It is of primary importance to reduce the size and weight of the parts in such torpedoes to the minimum, and to secure the maximum of energy from the motive power carried; because the available space is closely limited, and the range of the torpedo can only be added to by reducing the weight and increasing the efficiency of energy transformation. In order to increase the energy obtainable from the air carried in torpedoes propelled by compressed air, the air has sometimes been superheated before passing to the engine by burning in the air a certain amount of liquid fuel. But on account of the construction of the very light, high speed, powerful engines used in such torpedoes, the highest degree of heat theoretically obtainable is not practically available, since these engines must be operated at a moderate temperature. The result is that the fuel must be limited considerably below the amount which could combine with all the oxygen of the air in burning, and consequently the full efficiency of energy transformation is not secured.

The object of the present invention is to provide improved means whereby all the oxygen of the air may be used in combustion, or preferably, whereby compressed oxygen is carried instead of compressed air, and all of the oxygen is used for combustion; and then to overcome the objectionably high temperatures and preserve the released energy by providing means whereby the heat evolved by the combustion is utilized to form steam and the steam thus formed, with the cooled products of combustion, is delivered at the engine at a suitable temperature. By so doing, the total amount of work obtainable from the materials carried in the limited space of the torpedo will be largely increased, thereby largely increasing the range of the torpedo. It is further aimed to provide such means which admit of close regulation and safe control of the large forces employed; and to make it possible to continue the use of the light high speed powerful engines which are now used, and which require a very high working pressure and a moderate temperature.

The particular nature of the means employed will be understood from the following description and the accompanying drawings, in which there is described and illustrated the best form now known to me in which the invention may be embodied. The apparatus employed, however, is one which necessarily includes many known elements, and in which the different coöperating elements may assume many different equivalent forms.

In the drawings: Figure 1 is a top plan view of a portion of the torpedo, the shell being broken away to disclose the mechanism within it. Fig. 2 is a central longitudinal section on the line 2—2 of Fig. 1, with the generator and mixer in elevation. Fig. 3 is a cross section, on the line 3—3 of Fig. 1. Fig. 4 is a cross section on the line 4—4 of Fig. 1. Fig. 5 is a fragmentary cross section of the upper portion of the torpedo on the line 5—5 of Fig. 1, showing the fuel pump partly in section and partly in elevation. Fig. 6 is a longitudinal section (on the line 6—6 of Fig. 3) of the mixer and one of the safety devices. Fig. 7 is a fragmentary cross section on the line 7—7 of Fig. 1, showing the arrangement of valves of the fuel and water pumps. Fig. 8 is a cross section of the generator on the line 8—8 of Fig. 3. Fig. 9 is a cross section of one end of the generator on the line 9—9 of Fig. 1 showing another safety device, and Fig. 10 is an elevation partly in section and of a diagrammatic character, of the whole torpedo, showing the arrangement of the storage reservoirs, generator and engine in the torpedo.

The compressed air (or oxygen) is contained in a flask 1 formed by partitioning off a portion of the shell of the torpedo. From this flask the compressed air or oxygen is led to the generator through a starting valve 2, a reducing valve 3 and pipe 4.

The starting valve 2 is of known construction and is opened, upon launching the torpedo, by mechanical or other means, allowing the air (or oxygen) to pass through the reducing valve 3, which may be of any suitable construction and which reduces the air (or oxygen) to the working pressure. In the particular construction shown the starting valve is controlled through pipes 51 and 52 which extend to the ordinary tripping-latch cock (not shown). Up to this point the operation accords with the usual practice and no claims for novelty are made. The liquid fuel is carried in a suitable receptacle which in the form shown consists of two tanks 5 connected at their lower ends by an equalizing pipe 6 from which the fuel take-off pipe 7 leads. These flasks are provided with filling pipes 8 which branch from a filling orifice 9 closed by a screw-plug, when not in use. They are also provided with vent connections 10 extending to a vent orifice 11 which is also closed by a screw-plug when not in use. In filling, the vent and filling pipes are open; after filling they are closed. A connecting pipe 12 extends from the reduced air pressure to one of the branches of the vent pipes, thereby admitting the reduced air pressure to the flasks. The fuel take-off pipe 7 leads to one side of the fuel pump 13 and from the other side of that pump it is fed through the pipe 14 to the inlet 15 of the safety device in casing 54 (see Fig. 6) and through that device and the pipe 16 to the generator.

From Fig. 3 it will be seen that the air enters the burner of the generator through a tubular extension 17 of the pipe 4 which is surrounded by a chamber 18 with which the fuel supply pipe 16 communicates. The air or oxygen and the fuel, both under pressure, are forced through this tubular extension 17 and the surrounding space 18 against a cap 19 by which they are thrown out laterally in the form of a spray into the combustion chamber and are thoroughly mixed together. By means to be described later, the mixture of fuel and oxygen is ignited as soon as the torpedo is started. As the pressure in the combustion chamber is arranged to be four or five hundred pounds per square inch combustion will be very rapid. If pure oxygen be used instead of air, the resultant temperature would be very high. To withstand the high pressure the combustion chamber is made in the form of a strong cylinder 20. The intensely heated products of combustion pass from the combustion chamber through the open sleeve at the right hand end thereof (Fig. 3) into a strong perforated coil 21 which is within an outer casing 22 surrounding the combustion chamber. Water under pressure is supplied to this surrounding chamber through the water supply pipes 23 connected to the discharge orifices of the water pump 24 which is supplied from the external water through the pipes 25. This water is under sufficient pressure to be forced through the perforations in the pipe 21 against the pressure of the highly heated products of combustion therein, and the small streams of water flowing into the coil through the perforations mix with the heated gases, the water being converted into super-heated steam and the gases at the same time being cooled by the conversion. In other words, the water absorbs heat from the gases forming steam, so that the resultant mixture, while remaining at the working pressure, is of a lower temperature, and of greatly increased volume. The temperature of the steam and cooled gases will depend upon the proportion of oxygen, fuel and water used. From the coil 21 the gases pass into the mixer 26 (see Fig. 6) which comprises a chamber containing a series of gauze partitions 27. The object of the mixer is to heat up any drops of water which may be carried through the coil and cause them to form steam by contact with any strata of unduly heated gases which might get through the coil, and thus insure a uniform mixture at constant temperature being delivered at the engine through the pipe 77. It will be observed that the water in the outer chamber 22 serves to protect the combustion chamber from the heat inside, and also prevents the loss of heat by conduction, since such heat is absorbed by the water which subsequently passes into the coil to form steam.

The fuel pump 13 and the water pump 24 are both worked from the same yoke 28, carried to the main engine shaft 29, by the pinion 30 and the gear 31. Both of these pumps are of the single acting plunger type, with inlet check valves 55 and 57 and outlet check valves 56 and 58, and have an adjustable stroke provided by the adjusting screws 32 for the water pump and 33 for the fuel pump (see Fig. 2). It will be observed that by screwing in or out the screws 32 and 33 the distance at which the crank arms 34 and 35 are offset from the center is varied, thereby varying the extent of movement of the slotted yokes 36 and 37 and correspondingly varying the length of the pump stroke.

The ignition of the mixture of oxygen and fuel is accomplished, at starting, by means of the fuse 38 (see Fig. 3) in the carrier 39. The fuse is made of inflammable material such as cordite or smokeless powder and has on its end a percussion cap 40. When the torpedo is started and the air (or oxygen) under pressure enters the combustion chamber, the piston 41 is raised, the rod 42 is released, and is forced by the spring 43 in a direction to cause the striker 44 to explode the percussion cap and ignite the fuse,

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which thereupon starts the combustion of the mixed fuel and air or oxygen.

Safety devices are provided as follows:— To prevent injury from undue heat, such as would ensue should the supply of water fail from any cause, a fusible plug 45 (see Fig. 6) is inserted in the circuit of mixed steam and cooled gases. Under normal circumstances the temperature to which this plug is exposed will be well below its melting point. But when very high temperatures are met with, as when no water is supplied, this plug will melt before any other part of the apparatus is injured. When the plug melts, the passage normally closed by it will be opened. This passage leads to a cylinder 46 containing a piston 47 which is cut away at the central portion to afford, when in the position shown in Fig. 6, a communication from the fuel inlet 15 to the outlet communicating with the fuel pipe 16, as previously described. It will thus be seen that in this position the piston allows a free passage for the fuel from the fuel pump to the burner. When the plug is melted, the piston moves under pressure to the right in Fig. 6, and closes the exit passage for the fuel and puts the inlet passage into communication with the outlet 48 which leads overboard through the pipe 49. This action shuts off the supply of fuel to the burner and stops combustion. When this happens the torpedo will continue to run, using only the compressed air or oxygen as motive power. On account of the timing of ignition, or from other causes, there may occur at times in the combustion chamber very high pressures. To prevent injury, by relieving such pressure, a safety valve 50 of any suitable construction is attached to the sleeve forming the outlet from the combustion chamber (see Fig. 9).

The operation may be briefly described as follows:—In preparing the torpedo for use the tanks 1 and 5 are filled with compressed air or oxygen and with fuel, respectively, and all the parts are properly adjusted. As the torpedo leaves the firing tube the starting valve is lifted and the air or oxygen passes through the reducing valve, the generator, and the plate 17 into the engine to start it. At the same time, the pressure of the air or oxygen ignites the fuse. After the first few strokes of the engine, fuel and water will begin to flow. The mixture of fuel and air (or oxygen) coming in contact with the burning fuse will ignite; and thereafter the highly heated products of combustion have their heat absorbed by the water flowing through the perforations in the pipe 14 and the mixture of cooled gases and steam passes to the engine to operate it. It will be observed that this arrangement affords a means of attaining the maximum amount of mechanical work from a given amount of compressed fuel and oxygen-carrying substance; and that at the same time it admits of safe control and accurate regulation of the large forces employed, and can be used with the very light high speed powerful engines now used in torpedoes, which engines require a very high working pressure and moderate temperature.

Many of the coöperating parts of the apparatus described above are such as may be replaced by a skilled mechanic by equivalent parts of many different forms and yet retain the advantageous mode of operation of the invention, and I do not intend to limit myself to the use of the particular forms of apparatus disclosed; intending on the contrary to retain the liberty of availing myself of all other equivalent arrangements in which the invention may be embodied.

What I claim is:—

1. An apparatus for generating motive fluid for automobile torpedoes, comprising a strong inner casing forming a combustion chamber capable of withstanding high pressure and having means for supplying a combustible and an oxygen-carrier to said chamber and for igniting them therein, in combination with an outer casing surrounding said inner casing, a coiled perforated pipe surrounding the inner casing within the outer casing and forming an exit passage for the products of combustion, and means for supplying water under pressure to the space between the inner and outer casings whereby the water is forced in jets through the perforations into the products of combustion, and is converted into steam and mixed with the cooled gases; substantially as described.

2. In an apparatus for generating motive fluid for automobile torpedoes, a casing forming a combustion chamber and having means for supplying a combustible and an oxygen-carrier to said chamber in combination with a carrier supporting an ignition fuse having a percussion cap, a spring-actuated striker for said cap, a latch for restraining the striker, and mechanism actuated by pressure in the combustion chamber to release the latch and allow the striker to strike the percussion cap; substantially as described.

3. In an apparatus for generating motive fluid for automobile torpedoes, a casing 20 forming a combustion chamber and having a tubular inlet 17 for an oxygen carrier under pressure and a surrounding inlet 18 for a combustible under pressure, together with the deflecting plate 19 for throwing the mixed combustible and oxygen carrier into the combustion chamber in the form of a spray, a carrier 39 supporting an ignition fuse 38 having a percussion cap, a spring-actuated striker 44 normally restrained by a latch carried by a piston 41, the piston

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chamber being in communication with the combustion chamber, whereby pressure in the combustion chamber releases the striker, an outer casing 22 surrounding the casing 20, a perforated coiled pipe 21 in the space between the casing 22 and the casing 20 and forming an outlet from the combustion chamber, means for forcing water under pressure into the chamber between the two casings, whereby jets of water are forced through the perforations in the pipe 21 into the heated products of combustion from the combustion chamber to form steam and cool the products of combustion, a mixer in the path of the mixed steam and cooled gases, and a safety device also in the path of said gases operated by an excessively high temperature to shut off the supply of fuel to the generator; substantially as described.

4. A combined mixer and safety device for attachment to a generator of the character described comprising a casing 54 containing a chamber 26 in which gauze partitions 27 are supported, a fusible plug 45 normally closing a passage to a piston chamber 46 containing a piston 47 which controls the flow of fuel to the generator; substantially as described.

5. In an apparatus for generating motive fluid for automobile torpedoes, a casing forming a combustion chamber capable of withstanding high pressure and temperature and having means for supplying a combustible and an oxygen carrier to said chamber and for igniting them therein, a perforated extension of said chamber into which the hot products of combustion pass, a water jacket about said extension, and means for supplying water under pressure to said jacket, whereby the heated water in the water jacket is forced in jets through the perforations into the products of combustion, and is converted into steam and mixed with the cooled gases, substantially as described.

6. In an apparatus for generating motive fluid for automobile torpedoes, a casing forming a combustion chamber capable of withstanding high pressure and temperature and having means for supplying a combustible and an oxygen carrier to said chamber and for igniting them therein, a perforated extension of said chamber into which the hot products of combustion pass, a water jacket surrounding the combustion chamber and its extension, and means for supplying water under pressure to said jacket, whereby the heated water in the water jacket is forced in jets through the perforations into the products of combustion, and is converted into steam and mixed with the cooled gases, substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

GREGORY CALDWELL DAVISON.

Witnesses:
F. L. BRAKE,
W. D. FESLER.

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[fols. 129-133] Translation made by Translator of the State Department

GESZTEZY AIR WARMER FOR TORPEDOS—Omitted; printed side page 37

[fol. 134] C–14 To Court's findings.

(Here follow side folio pages 135-144, inclusive.)

[fol. 145] SUPREME COURT OF THE UNITED STATES

[Title omitted]

STIPLUATION FOR ADDITION TO RECORD—Filed Nov. 20, 1923

It is hereby stipulated and agreed by and between counsel for the parties hereto that Exhibit C-3 referred to in Finding XIV of the Findings of Fact, be added to the record herein on appeal from the judgment of the United States Court of Claims.

Dean S. Edwards, Counsel for Appellant. James M. Beck, Counsel for Appellee. Dated November 20, 1923.

Approved. H. E. K.

[File endorsement omitted.]

SUPREME COURT OF THE UNITED STATES, OCTOBER TERM, 1923

No. 159

ELECTRIC BOAT COMPANY, Appellant,

v.

THE UNITED STATES, Appellee

STIPULATION TO CORRECT RECORD

It is hereby stipulated and agreed by and between Counsel for the parties hereto that British Patent No. 15977 of 1906 included as Exhibit C-8 on pages 48, 49 and first four (4) lines of page 50 of the record be removed therefrom, and British Patent No. 15997 of 1906, which is the correct Exhibit C-8, be inserted in its place without renumbering the remaining pages of the record.

It is further stipulated and agreed that the index be corrected accordingly without reprinting the same.

A copy of British patent No. 15997 of 1906 is attached hereto.

Dean S. Edmonds, Counsel for Appellant. James M. Beck, Counsel for Appellee. H. E. K.

Dated January 2nd, 1924.